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ANTENNA MODELING PROGRAM SUPPLEMENTARY COMPUTER PROGRAM MANUAL --ETC(U)

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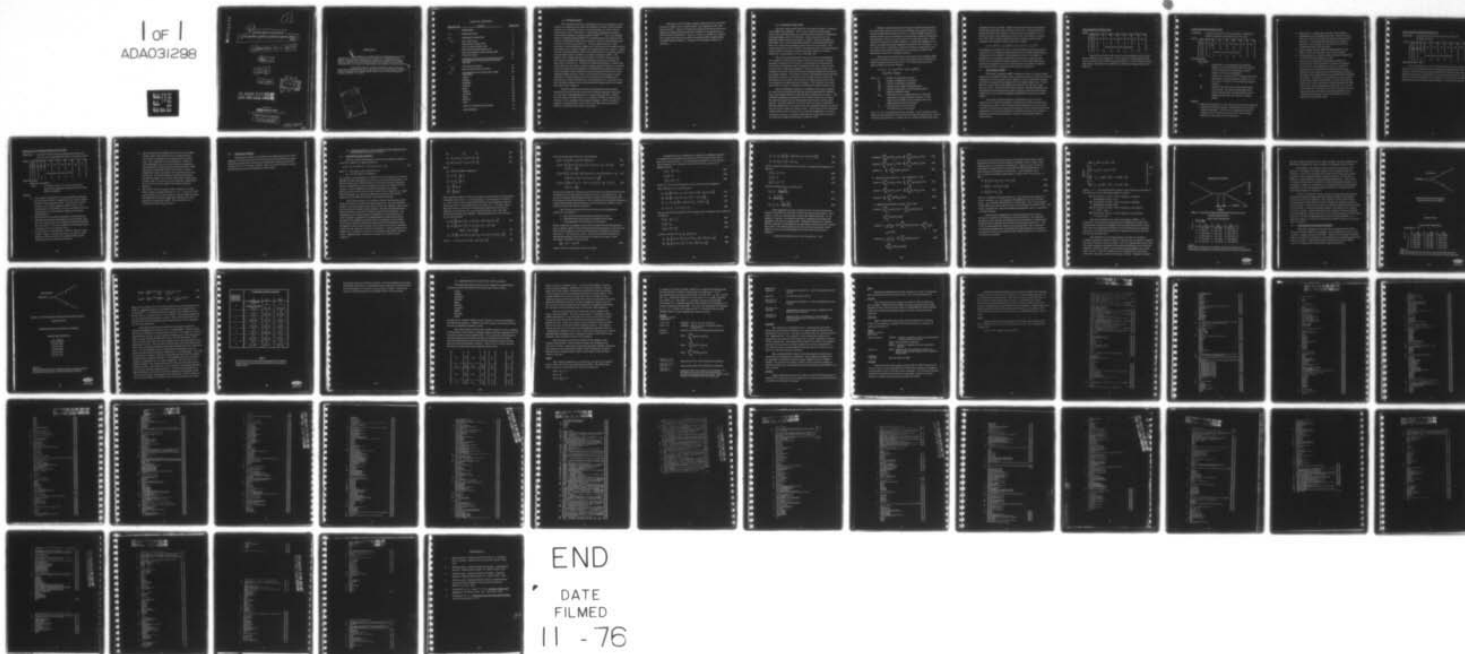
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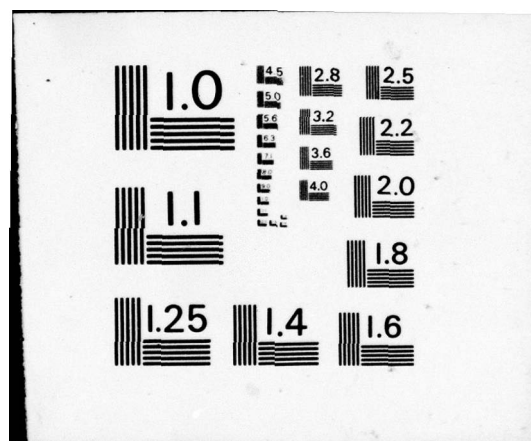
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ANTENNA MODELING PROGRAM
SUPPLEMENTARY COMPUTER PROGRAM MANUAL (AMPJ).

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MB-R-75/37

12 58p.

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Apr 1975

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FOREWORD

This manual is a supplement to the Engineering, User's and Systems manuals prepared for the Antenna Modeling Program (AMP), and describes the operation, theory and coding of the changes made to AMP for more accurate treatment of multiple wire junctions and reduction of the time for interaction calculations on large structures.

The AMP code as modified (AMPJ) has been delivered to the Naval Ship Engineering Center and U.S. Army Strategic Communications Command and was developed under Office of Naval Research Contract N00014-71-C-0187.

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1.0 INTRODUCTION

Wire antennas and their supporting structures frequently include junctions of several wires connected together at a point. Such multiple junctions are especially common when wire grids are used to model solid surfaces as is often done in mathematical modeling of antennas. The antenna modeling computer program AMP^{1, 2, 3} for wire antennas and the extended program AMP2⁴ for modeling wires and surfaces both allow for modeling multiple wire junctions, and have demonstrated good results for many such structures. In some cases, however, when segments of greatly different lengths have been joined at multiple junctions the method used in these programs has yielded inaccurate results. Hence a more careful treatment of the current interpolation at multiple junctions was developed and is included as an option in program AMPJ. The details of this method are given in Section 3.0 of this manual and the data cards to request the optional treatment at specific junctions are described in Section 2.0. Although the optional technique is numerically more stable for the general case of unequal segment lengths at a junction, it was not included in the extended code AMP2 for the following reasons: 1) the technique used in AMP2 has demonstrated good results for equal segment lengths and has a good record; 2) the new technique as implemented for testing requires an extra unknown at each multiple wire junction where used, and there are many junctions in a wire grid; 3) the new technique requires more development and testing which was outside the scope of this contract.

Program AMPJ also includes an approximate matrix filling method that may be used for interactions between segments separated by more than a specified distance to reduce matrix fill time. Hence the only feature of AMP2 that is not available in AMPJ is modeling of surfaces via the magnetic field integral equation. AMPJ includes all features of program AMP and in addition the optional junction interpolation and approximate matrix fill method.

Section 2.0 of this manual contains instructions for use of the features of AMPJ not in program AMP, and supplements the AMP Users Manual¹. Section 3.0 gives the equations for the junction interpolation and approximate matrix fill methods, and supplements the AMP Engineering Manual². Finally, section 4.0 details the coding of the routines that differ from those in program AMP, supplementing the AMP Systems Manual³. Listings of the changed routines are included.

2.0 PROGRAM OPERATION

The basic information needed to use program AMPJ is contained in the AMP Users Manual¹. This section contains supplementary instructions and information for using the optional junction interpolation and approximate matrix fill methods. If the new options are not required, AMPJ may be used exactly as AMP. The one exception is that AMPJ uses a time saving approximation in filling the interaction matrix for interaction distances greater than one wavelength. For results identical to those of AMP in all digits printed, this approximation range should be increased to greater than the maximum structure dimension in wavelengths by use of a KH data card.

The standard interpolation method involves the extrapolation of a segment current by the average distance of the centers of other segments connected to the junction, requiring that the extrapolated current for the segment equal the negative of the sum of the currents at the centers of the other segments. Because of the average, this technique can lead to problems when the segment lengths at the junction are greatly unequal. The optional junction interpolation method satisfies Kirchhoff's Current Law directly at the junction and also forces the derivatives of the current with respect to distance at the ends of each of the segments at the junction to be equal. The condition on current derivatives is based on continuity of potential for equal segment radii.

Since an additional unknown is required in the matrix equation for each junction at which the optional junction interpolation method is used, this method should be used only when required for accuracy. The standard interpolation method has been found to work well as long as the connected segments at multisegment junctions have nearly equal lengths. Results in Section 3.0 show an error of about 15 percent in the input admittance of an antenna when the segment lengths at a junction near the source differ by a factor of two. The accuracy of the computed radiated field is less sensitive to the segment lengths than is current. In general, however, segment lengths should be kept within a factor of two when the standard interpolation method is used.

With the optional junction interpolation method limited testing has shown that good accuracy may be obtained with segment lengths at a junction differing by factors of 8 to 10. With the AMPJ program an antenna model may conveniently be run both with standard and optional interpolation methods to test the need for the optional method. When complex structures are being modeled, it is quite advantageous to be able to use different length segments at junctions with confidence. As a result it may be possible to reduce the number of segments so that the matrix size and the running time are decreased in spite of the additional unknowns for multiple junctions.

The program execution time is the same as for program AMP except for differences due to use of the optional junction interpolation method and approximate matrix fill. The central processor time approximately follows the formula

$$T = Ak (1 - 0.7 R_w) N^2/M + B (N + N_j)^3/M^2 + CN_e N^2/M + DkN_f N$$

- where
- N = number of segments in model
 - M = number of degrees of symmetry
 - N_e = number of different excitations
 - N_f = number of far field calculation points
 - N_j = number of junctions at which optional interpolation method is used
 - R_w = the fraction of all segment pairs for which the separation is greater than R_0 where R_0 is the limit set on the KH card for change over to the approximate matrix fill method.
 - k = 1 if structure is in free space
2 if structure is over ground

and A, B, C, D are proportionality constants. The first term in this equation represents the time for matrix filling; the second term, matrix factoring; the third term, solution for the current and the fourth term,

calculation of the far fields. Each term represents only the dominant component neglecting terms of lower order in N . The proportionality factors depend on the computer system on which the program is run. To give an idea of the importance of the terms, the factors in seconds for a CDC 6600 computer with the program compiled under the Run compiler and the matrix fitting in core are roughly

$$A = 2 \times 10^{-3}, B = 5 \times 10^{-6}, C = 2 \times 10^{-5}, D = 3 \times 10^{-4}$$

If an antenna is analyzed for only a single excitation and the far field is computed at a few angles the execution time will consist almost entirely of the time to fill and factor the interaction matrix. If a number of excitations are requested, especially for out of core solutions, the time to solve the factored matrix equation for the current distribution can become significant, and if a large number of far field calculations are requested their computation time must be considered.

2.1 NEW INPUT CARDS

The input to program AMPJ is identical to that for program AMP except for the addition of data cards to specify junctions at which the optional interpolation of the current is to be applied, and the separation distance at which the matrix filling changes over to an approximate form. Hence the user should refer to the AMP Users Manual¹ for the basic input data structure. If only the basic data cards are used the interpolation at all junctions will be the same as that in program AMP and approximate matrix fill will be used for segments separated by more than one wavelength.

To specify matched derivative interpolation at one of more junctions a one must be punched in column 10 of the GE card at the end of the geometry data. This card may be followed by one or more cards with the mnemonic JX to specify the junctions at which matched derivative interpolation is desired and finally a card with mnemonic JE to indicate the end of junction specifications. The form of these data cards is shown below.

END GEOMETRY INPUT (GE)

CARD:

2	5	10	20	30	40	50	60	70	80
GE	I1	I2	Blank	Blank	Blank	Blank	Blank	Blank	Blank

The numbers along the top refer to the last column in each field.

The function of this card is the same as in program AMP except for the addition of the integer I2. If I2 is equal to 1 the program reads junction specification cards following the GE card. If I2 is blank standard data cards, described in the AMP User's Manual are expected after the GE card.

JUNCTION SPECIFICATION (JX)

PURPOSE: to specify segment junctions (simple or multiple) at which the optional interpolation is to be used.

CARD:

2	5	10	15	20	30	40	50	60	70	80
JX	IX	IY	IZ	Blank	Blank	Blank	Blank	Blank	Blank	Blank

The numbers along the top refer to the last column in each field.

PARAMETERS:

INTEGERS

- IX** - tag number of one segment at the junction. Blank or zero for IX implies that the segment will be identified by the absolute segment number in the next location (IY).
- IY** - equal to m, specifies the mth segment of the set of segments with tag numbers equal to IX. If IX is zero or blank, IY is the absolute segment number.
- IZ** - specifies the end of the segment determined by IX and IY. IZ equal to 2 specifies end 2 of the segment and 1 or blank specifies end 1 (reference direction for current is toward end 2).

NOTES:

- Optional interpolation is used for the junction at the specified end of the specified segment. The junction may be either simple or multiple. A JX card is required for only one segment end at a junction to cause use of optional interpolation for all segments at the junction.

- If IX and IY are blank, the card will cause optional interpolation at all multiple junctions. Such a JX card must occur before any other JX cards specifying simple junctions. For optional interpolation at all multiple junctions but no simple junctions the JX card may be omitted with only a JE card used.
- Each junction at which optional interpolation is used adds an additional unknown in the matrix equation.
- All segments at a junction at which optional interpolation is used should have equal wire radii.
- When using the optional interpolation method on a structure for which symmetry is used in the solution, any junctions to be specified in the first symmetric section must be specified first followed by the same junctions in the second section and continuing through all sections in the order that they were produced by reflection or rotation. In addition, the junctions must be specified in the same order in each section. If only a JE card (no JX card) is used to specify all multiple segment junctions these rules will automatically be satisfied. Use of a JX card with IX and IY blank to specify all multiple junctions followed by other JX cards for simple junctions is not allowed with symmetry since the junctions will not be specified in the proper order.

END JUNCTION SPECIFICATION (JE)

PURPOSE: to mark the end of the JX cards or specify all multiple junctions.

CARD:

2	5	10	15	20	30	40	50	60	70	80
JE	Blank	Blank	Blank	Blank	Blank	Blank	Blank	Blank	Blank	Blank

The numbers along the top refer to the last column in each field.

PARAMETERS: None

If a 1 is punched in column 10 of the GE card then a JE card is required to return the program to reading the standard input cards. If one or more JX cards are used the JE card is placed at the end of the JX cards and its only function is to mark the end of these cards. If no JX cards are used the JE card alone will cause the use of optional interpolation at all multiple junctions (three or more wires joined).

INTERACTION APPROXIMATION RANGE (KH)

PURPOSE: to set the minimum segment separation distance for use of a time saving approximation in filling the matrix.

CARD:

2	5	10	15	20	30	40	50	60	70	80
KH	Blank	Blank	Blank	Blank	RKH	Blank	Blank	Blank	Blank	Blank

The numbers along the top refer to the last column in each field.

PARAMETERS:

DECIMAL NUMBERS

RKH - The approximation is used for interaction between two segments separated by more than RKH wavelengths.

NOTES:

- For segments separated by more than RKH wavelengths the interaction field is computed from an impulse approximation to the segment current. The field of a current element located at the segment center is used. For separations less than RKH a current interpolation function is integrated over the segment length as in the basic AMP program.
- The KH card can be placed anywhere in the data cards following the geometry and junction cards (with FR, GN, EX, etc.) and affects all calculations requested following its occurrence. The value of RKH may be changed within a data set by use of a new KH card.
- If no KH card is used RKH has a default value of 1 wavelength. Hence to exactly duplicate a run with the AMP program a KH card should be used with RKH greater than the maximum structure dimension.

- The minimum value of RKH which can be used to obtain results within a few percent of the no approximation case seems to depend to some extent on the structure size, type, segmentation, and excitation. Values of .25 wavelengths or less have been found acceptable for symmetrically excited structures and electrically small wire grids; on the other hand, values up to .5 wavelengths have been required for very asymmetrically fed structures. No exact guidelines have been developed for RKH; therefore, it is best to experiment on any given problem type if a minimum value is desired. RKH should never be less than the length of the longest segment, however.
- The matrix fill time using the RUN compiler on a CDC 6600 computer is approximately $T_f = (2. - 1.4R_w) (10^{-3}) N^2$ seconds where R_w is the number of segment pairs for which the separation is greater than RKH, divided by the total number of segment pairs (N^2). Thus the fill time is decreased by about $70R_w$ percent.

2.2 PROGRAM OUTPUT

The program output is essentially unchanged from the basic deck. Segments connected to junctions at which optional interpolation has been specified are indicated in the block of segmentation data by connection numbers (I+ or I-) less than -90,000. Also, the value of RKH is printed following the printing of frequency and wavelength.

3.0 FORMULATION OF THE INTERPOLATION METHOD AND APPROXIMATE MATRIX FILLING

3.1 INTERPOLATION METHOD

For the current interpolation method used in program AMP the current on segment j is approximated as

$$I_j(s) = A_j + B_j \sin k(s - s_j) + C_j \cos k(s - s_j) \quad (1)$$

where $k =$ free space wave number ($2\pi/\lambda$)

$s_j = s$ at the center of segment j .

A_j , B_j and C_j are constants to be determined so that equation (1) yields the best possible approximation to the true current on the segment. Of the $3N$ constants to be determined for a structure having N segments, $2N$ are eliminated by enforcing conditions on the local behavior of the current. These conditions are used to eliminate the constant A_j and C_j in terms of the current at the center of each segment, $I_j = I_j(s_j)$. The N unknowns, I_j , are then computed by solution of the matrix equation derived from the electric field integral equation.

In the basic program the condition used to eliminate two of the three unknowns for a segment is that equation (1), when extrapolated forward over the distance to the center of the next segment, must match the current of the center of that segment, and when extrapolated back must match the current at the center of the previous segment. At a multiple junction, where an end of segment j is connected to two or more segments, equation (1) is extrapolated a distance equal to the average of the distances from the center of segment j to the centers of all other segments connected to the junction and required to equal the algebraic sum of the currents at the centers of the other segments, relative to the reference direction of segment j . These conditions are based on the continuity of current at the junction (Kirchhoff's Current Law). Applying these conditions to equation (1) yields the three equations

$$A_j + C_j = I_j \quad (2)$$

$$A_j - B_j \sin k \delta_j^- + C_j \cos k \delta_j^- = K_j^- \quad (3)$$

$$A_j + B_j \sin k \delta_j^+ + C_j \cos k \delta_j^+ = K_j^+ \quad (4)$$

where

Δ_j = half the length of segment j

$$\delta_j^- = \Delta_j + \frac{1}{n_-} \sum_l \Delta_l$$

$$\delta_j^+ = \Delta_j + \frac{1}{n_+} \sum_k \Delta_k$$

$$K_j^- = \sum_l (\pm I_l)$$

$$K_j^+ = \sum_k (\pm I_k)$$

The summation index l takes on the values of the numbers of all segments connected to the first or - end of segment j , of which there is a total of n_- , and k takes on the values of the numbers of all segments connected to the second or + end of which there is a total of n_+ . The plus sign in the summation of currents is used when the reference directions for segment j and segment l or k are parallel and the minus sign when reference directions are opposed. Solving equations (2), (3) and (4) for A_j , B_j and C_j yields

$$A_j = \frac{1}{\Delta} \left[K_j^- \sin k \delta_j^+ - I_j \sin k (\delta_j^- + \delta_j^+) + K_j^+ \sin k \delta_j^- \right] \quad (5)$$

$$B_j = \frac{1}{\Delta} \left[K_j^- (\cos k \delta_j^+ - 1) + I_j (\cos k \delta_j^- - \cos k \delta_j^+) + K_j^+ (1 - \cos k \delta_j^-) \right] \quad (6)$$

$$C_j = \frac{-1}{\Delta} \left[K_j^- \sin k \delta_j^+ - I_j (\sin k \delta_j^- + \sin k \delta_j^+) + K_j^+ \sin k \delta_j^- \right] \quad (7)$$

$$\text{where } \Delta = \sin k \delta_j^- + \sin k \delta_j^+ - \sin k (\delta_j^- + \delta_j^+) \quad (8)$$

To solve for the I_j the terms are regrouped as

$$I_j(s) = K_j^- X_j(s) + I_j Y_j(s) + K_j^+ Z_j(s) \quad (9)$$

$$X_j(s) = \frac{1}{\Delta} \left[\sin k \delta_j^+ + (\cos k \delta_j^+ - 1) \sin k(s - s_j) - \sin k \delta_j^+ \cos k(s - s_j) \right] \quad (10)$$

$$Y_j(s) = \frac{1}{\Delta} \left[-\sin k(\delta_j^- + \delta_j^+) + (\cos k \delta_j^- - \cos k \delta_j^+) \sin k(s - s_j) + (\sin k \delta_j^- + \sin k \delta_j^+) \cos k(s - s_j) \right] \quad (11)$$

$$Z_j(s) = \frac{1}{\Delta} \left[\sin k \delta_j^- + (1 - \cos k \delta_j^-) \sin k(s - s_j) - \sin k \delta_j^- \cos k(s - s_j) \right] \quad (12)$$

The electric fields for filling the interaction matrix are obtained in the form of equation (9) by replacing the constant, $\sin k(s - s_j)$ and $\cos k(s - s_j)$ terms in equations (10) through (12) by the fields at the observation point due to these current distributions. The coefficient of each I_j then represents a contribution to the matrix element in row i and column j where i is the segment at which the field is evaluated.

The optional interpolation method enforces the following two conditions at a junction.

1. The sum of currents leaving the junction is zero.
2. The derivatives with respect to distance at the ends of all segments at the junction are set equal.

These conditions are applied at the junction rather than by extrapolating to the segment centers, thus eliminating the discontinuities at the junctions. The second condition is based on the continuity of potential as stated in reference 5. For equal wire radii, continuity of potential implies that the charge densities on the wire ends at a junction are equal, which through the continuity of current law,

$$\frac{\partial}{\partial s} I(s) = -j\omega q(s) \quad (13)$$

implies that the current derivatives are equal.

To apply these two conditions at a junction an additional unknown is introduced representing the derivative of the current on the end of each wire at the junction. For the optional interpolation on the positive end of segment j the conditions used to determine A_j , B_j and C_j in equation (1) are

$$I_j(s_j - \delta_j^-) = K_j^- \quad (14)$$

$$I_j(s_j) = I_j \quad (15)$$

$$I_j'(s_j + \Delta_j) = \alpha_j^+ \quad (16)$$

where α_j^+ = the current derivative at the positive end of segment j

The solutions for A_j , B_j and C_j are

$$A_j = \frac{1}{D} \left[K_j^- \cos k \Delta_j - I_j \cos k (\Delta_j + \delta_j^-) + \alpha_j^+ \sin k \delta_j^- \right] \quad (17)$$

$$B_j = \frac{1}{D} \left[(I_j - K_j^-) \sin k \Delta_j + \alpha_j^+ (1 - \cos k \delta_j^-) \right] \quad (18)$$

$$C_j = I_j - A_j = \frac{1}{D} \left[(I_j - K_j^-) \cos k \Delta_j - \alpha_j^+ \sin k \delta_j^- \right] \quad (19)$$

$$D = \cos k \Delta_j - \cos k (\Delta_j + \delta_j^-) \quad (20)$$

For the optional interpolation on the negative end of segment j the conditions on $I(s)$ are

$$I_j'(s_j - \Delta_j) = \alpha_j^- \quad (21)$$

$$I_j(s_j) = I_j \quad (22)$$

$$I_j(s_j + \delta_j^+) = K_j^+ \quad (23)$$

and the solutions for A_j , B_j , and C_j are

$$A_j = \frac{1}{D} \left[\alpha_j^- \sin k \delta_j^+ + I_j \cos k (\Delta_j + \delta_j^+) - K_j^+ \cos k \Delta_j \right] \quad (24)$$

$$B_j = \frac{1}{D} \left[\alpha_j^- (\cos k \delta_j^+ - 1) + (I_j - K_j^+) \sin k \Delta_j \right] \quad (25)$$

$$C_j = I_j - A_j = \frac{1}{D} \left[(I_j - K_j^+) \cos k \Delta_j + \alpha_j^- \sin k \delta_j^+ \right] \quad (26)$$

$$D = \cos k (\Delta_j + \delta_j^+) - \cos k \Delta_j \quad (27)$$

For the optional interpolation on both ends of segment j the conditions on $I(s)$ are

$$I_j' (s_j - \Delta_j) = \alpha_j^- \quad (28)$$

$$I_j (s_j) = I_j \quad (29)$$

$$I_j' (s_j + \Delta_j) = \alpha_j^+ \quad (30)$$

and the solutions for A_j , B_j and C_j are

$$A_j = I_j - \frac{\alpha_j^- - \alpha_j^+}{2 \sin k \Delta_j} \quad (31)$$

$$B_j = \frac{\alpha_j^- + \alpha_j^+}{2 \cos k \Delta_j} \quad (32)$$

$$C_j = I_j - A_j = \frac{\alpha_j^- - \alpha_j^+}{2 \sin k \Delta_j} \quad (33)$$

These equations give the constants for the current interpolation function of equation (1) once the current values I_j have been found. They could be used as a starting point to obtain the matrix elements. In the program, however, the matrix elements are obtained by starting with equations in the form of equation (9). Taking the derivative of equation (9) with respect to s and applying the appropriate conditions at the segment ends leads to the following expressions for the matrix element contributions for the row corresponding to the field observation point on segment i :

1. Optional interpolation on + end, standard on - end

$$\text{column } i: \int_{-\Delta_j}^{\Delta_j} G_i(s) X_j(s) ds - \frac{Z}{X} \int_{-\Delta_j}^{\Delta_j} G_i(s) Z_j(s) ds \quad (34)$$

$$\text{column } j: \int_{-\Delta_j}^{\Delta_j} G_i(s) Y_j(s) ds - \frac{Y}{X} \int_{-\Delta_j}^{\Delta_j} G_i(s) Z_j(s) ds \quad (35)$$

$$\text{column } \alpha: -\frac{1}{X} \int_{-\Delta_j}^{\Delta_j} G_i(s) Z_j(s) ds \quad (36)$$

2. Optional interpolation on - end, standard on + end

$$\text{column } k: \int_{-\Delta_j}^{\Delta_j} G_i(s) Z_j(s) ds - \frac{Z}{X} \int_{-\Delta_j}^{\Delta_j} G_i(s) X_j(s) ds \quad (37)$$

$$\text{column } j: \int_{-\Delta_j}^{\Delta_j} G_i(s) Y_j(s) ds - \frac{Y}{X} \int_{-\Delta_j}^{\Delta_j} G_i(s) X_j(s) ds \quad (38)$$

$$\text{column } \alpha: \frac{1}{X} \int_{-\Delta_j}^{\Delta_j} G_i(s) X_j(s) ds \quad (39)$$

3. Optional interpolation on both - and + ends

$$\begin{aligned} \text{column } j: & \int_{-\Delta_j}^{\Delta_j} G_i(s) Y_j(s) ds - \int_{-\Delta_j}^{\Delta_j} G_i(s) X_j(s) ds \\ & + \int_{-\Delta_j}^{\Delta_j} G_i(s) Z_j(s) ds \end{aligned} \quad (40)$$

$$\begin{aligned} \text{column } \alpha_-: & \frac{1}{X^2 - Z^2} \left(X \int_{-\Delta_j}^{\Delta_j} G_i(s) X_j(s) ds - Z \int_{-\Delta_j}^{\Delta_j} G_i(s) \right. \\ & \left. Z_j(s) ds \right) \end{aligned} \quad (41)$$

$$\begin{aligned} \text{column } \alpha_+: & \frac{1}{X^2 - Z^2} \left(X \int_{-\Delta_j}^{\Delta_j} G_i(s) X_j(s) ds - \right. \\ & \left. Z \int_{-\Delta_j}^{\Delta_j} G_i(s) Z_j(s) ds \right) \end{aligned} \quad (42)$$

For each case $G_i(s)$ is the component of the free space dyadic Green's function for the electric field tangent to segment i at the center of that segment due to a current at s on segment j . $X_j(s)$, $Y_j(s)$, $Z_j(s)$ are as defined in equations (10) through (12) with the exception that $\delta_j^- = \Delta_j$ when optional interpolation is used on the - end of segment j and $\delta_j^+ = \Delta_j$ when the optional interpolation is used on the + end, and $s_j = 0$. Also

$$X = \frac{k}{\Delta} [\cos k (\Delta_j + \delta_j) - \cos k \Delta_j] \quad (43)$$

$$Y = \frac{k}{\Delta} [1 - \cos k (\Delta_j + \delta_j)] \quad (44)$$

$$Z = \frac{k}{\Delta} [\cos k \Delta_j - 1] \quad (45)$$

where Δ is defined in equation (8) and $\delta_j = \delta_j^+$ if optional interpolation is on the - end only, $\delta_j = \delta_j^-$ if optional interpolation is on the + end only, and $\delta_j = \Delta_j$ if optional interpolation is on both ends. The column indices l and k take the values of the numbers of all segments connected to the - and + ends, respectively, when the standard interpolation end of a segment is a multiple junction.

The columns designated by α represent the unknown current derivative common to all segment ends at the junction. An additional equation for this unknown is obtained from the derivative of equation (9) evaluated at the segment end at which the current derivative is α . K_j^+ or K_j^- is replaced by the current at the segment end. By forming the sum of these equations for each segment at the junction the currents at the segment ends are eliminated by the condition that their sum be zero, leading to the equation

$$\sum_{j=1}^M \left\{ \begin{array}{l} \textcircled{1} \quad I_{l_j} Z/X + I_j Y/X + \alpha/X \\ \text{or} \\ \textcircled{2} \quad -I_{k_j} Z/X - I_j Y/X + \alpha/X \\ \text{or} \\ \textcircled{3} \quad -I_j - \alpha X/(Z^2 - X^2) - \alpha^- Z/(Z^2 - X^2) \\ \text{or} \\ \textcircled{4} \quad I_j - \alpha X/(Z^2 - X^2) - \alpha^+ Z/(Z^2 - X^2) \end{array} \right\} = 0 \quad (46)$$

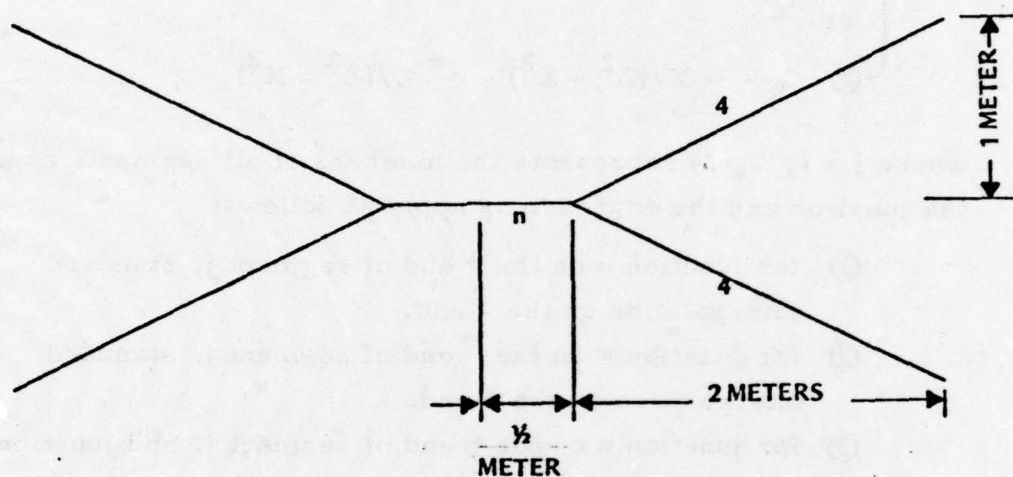
where $j = 1, \dots, M$ represents the numbers of all segments connected to the junction and the expressions apply as follows:

- ① for junction α on the + end of segment j , standard interpolation on the - end.
- ② for junction α on the - end of segment j , standard interpolation on the + end.
- ③ for junction α on the + end of segment j , and junction α^- on the - end.
- ④ for junction α on the - end of segment j , and junction α^+ on the + end.

The above equations are used in the program AMPJ. It is possible to eliminate the current derivative unknowns (α) rather than include them in the set of equations solved numerically but this is difficult if the new interpolation method is used on both ends of a segment. Also, the code could be generalized for unequal wire radii at junctions but this has not been done.

The stability of the two interpolation methods for modeling multiple junctions is shown in Tables 1 through 3 for an antenna composed of a linear element, fed at the center, with vee shaped loads on each end. The input impedance computed with standard interpolation at all segment junctions is shown in Table 1 for varying segment lengths on the entire center section. For this model there are 4 segments on each of the arms and n segments on half of the center element. Though no attempt

NUMERICAL TEST ANTENNA



WHEN $n = 1$, JUNCTION SEGMENTS ARE APPROXIMATELY EQUAL IN LENGTH

2 SEGMENT SOURCE IS USED

TABLE OF INPUT IMPEDANCE/2.

n	FREQ. (MHz)		
	270	280	290
1	$33.5 + j79.5$	$36.7 + j95.4$	$40.0 + j111.$
2	$35.8 + j93.$	$39.5 + j110.$	$43.4 + j126.8$
4	$33.2 + j119.6$	$36.8 + j135.$	$40.6 + 150.4$
6	$28.2 + j152.5$	$31.1 + j165.$	$34.2 + j177.5$
8	$21.7 + j190.2$	$23.8 + j199.5$	$26.0 + j208.6$
10	$13.9 + j233.$	$15.1 + j237.9$	$16.3 + j243.2$

TABLE 1
INPUT IMPEDANCE OF TEST ANTENNA USING STANDARD JUNCTION
INTERPOLATION SCHEME FOR VARIOUS SEGMENT LENGTHS AT JUNCTION

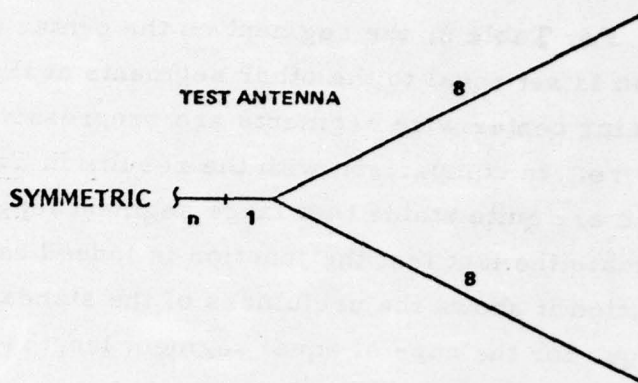
has been made to keep the source width constant, the input impedance of the structure should not vary as rapidly as indicated by these results.

For Table 2, the segment on the center wire connected to the junction is set equal to the other segments at the junction while the remaining center wire segments are progressively decreased in length as before. In comparison with the results in Table 1, the results in Table 2 are quite stable to a large segment length factor. This serves to validate the fact that the junction is indeed causing the problem, and in addition it shows the usefulness of the standard junction interpolation technique for the case of equal segment lengths at a multiple junction and unequal segments elsewhere.

Table 3 contains the results obtained using the new interpolation technique at the two multiple junctions and the standard interpolation at all junctions of two segments. The segments on the center section are progressively decreased in length including the segment connected to the junction. These results show much greater stability than the results given in Table 1 where the segment lengths at the junction are varied in a similar manner. On the other hand, the results for the new technique are somewhat less stable than for the case of equal segments at the junction (Table 2), but when complicated structures are being modeled, it is quite advantageous to be able to use different length segments at junctions with confidence.

3.2 APPROXIMATE MATRIX ELEMENTS

When wire segments in a structure are distant from an observation point with respect to wavelength, simple expressions can be used to obtain accurate values for the fields. This fact can be used to substantially reduce the time required in calculating the corresponding interaction matrix elements. The following expressions are used in the AMPJ code when segment-observation point separation permits:



SEGMENTS AT THE MULTIPLE WIRE JUNCTION
ARE APPROXIMATELY EQUAL IN LENGTH

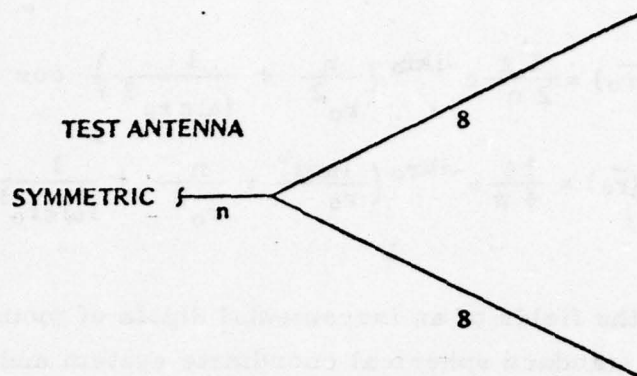
2 SEGMENT SOURCE

TABLE OF INPUT IMPEDANCE/2.

FREQ. (MHz) →				
n		270	280	290
1	↓	34.4 + j80.3	37.9 + j96.7	41.7 + j112.9
2		35.1 + j80.8	38.8 + j97.5	42.9 + j114.1
4		35.4 + j81.	39.4 + j98.	43.7 + j115.
6		35.6 + j82.2	39.5 + j98.6	43.9 + j115.7
8		35.6 + j83.8	39.6 + j98.6	43.9 + j112.4
10		35.9 + j99.	39.6 + j97.8	44.1 + j121.9

TABLE 2
INPUT IMPEDANCE OF TEST ANTENNA USING STANDARD JUNCTION
INTERPOLATION SCHEME FOR AN EQUAL SEGMENT LENGTH JUNCTION





WHEN $n = 2$, JUNCTION SEGMENTS LENGTHS ARE APPROXIMATELY EQUAL.

2 SEGMENT SOURCE

CURRENTS AND DERIVATIVES MATCHED AT JUNCTION

TABLE OF INPUT IMPEDANCE /2.

n	f = 270 MHz
2	34.5 + j78.9
4	36.1 + j77.6
6	37.0 + j76.9
8	37.7 + j76.1
10	38.1 + j75.4

TABLE 3
INPUT IMPEDANCE OF TEST ANTENNA USING THE NEW JUNCTION
TECHNIQUE FOR UNEQUAL JUNCTION SEGMENT LENGTHS

MBA

0425-13268

$$E_r(\bar{r}_0) = \frac{I \ell}{2 \pi} e^{-ikr_0} \left(\frac{\eta}{r_0^2} + \frac{1}{i\omega \epsilon r_0^3} \right) \cos \theta \quad (47)$$

$$E_\theta(\bar{r}_0) = \frac{I \ell}{4 \pi} e^{-ikr_0} \left(\frac{i\omega \mu}{r_0} + \frac{\eta}{r_0^2} + \frac{1}{i\omega \epsilon r_0^3} \right) \sin \theta \quad (48)$$

These are the fields of an incremental dipole of moment $I\ell$ located at the origin of a standard spherical coordinate system and oriented in the z direction⁽⁶⁾. At sufficient distances equations (47) and (48) are used for the field of a segment where ℓ is set equal to the segment length and I is set equal to the center point current. Thus, these expressions are the same as would be obtained using a pulse function current expansion and one step integration.

This approximation has been found to yield good results for separation distances as small as .25 to .2 wavelengths. Table 4 shows the accuracy obtained for a particular structure, a 2λ dipole, for various segmentations and for various separation distances for which the expressions in equations (47) and (48) were used. The KH parameter in the table specifies the distance at which change over to the approximate field expressions occurs. The column on the left hand side of the table shows the number of segments away from the field segment which are integrated over. For this example it can be seen that the impedance accuracy remains within a few percent for a KH down to .21 wavelengths. It should be pointed out, however, that due to the quantized nature of the problem a KH parameter slightly less than .2 wavelengths will cause an abrupt change to integration over one fewer segments. For the case of .2 λ segment lengths, this means integration for the self term only and the results are poor. This problem can be avoided by keeping the KH parameter larger than the longest segment. It should also be pointed out that the minimum value for KH seems to depend to some extent on the structure size, type, segmentation, and excitation. Values of KH up to .5 λ have been necessary to obtain only a few percent error for some

NUMBER OF SEGMENTS INCLUDED	STRUCTURE SEGMENT LENGTHS		
	0.2	0.1	0.05
0	KH PARAMETER .01	.01	.01
	% ERROR REAL, IMAG. 47.2, 53.	77.3, 135.	97.4, 170.4
1	.21	.11	.06
	2.2, .62	12.4, 12.4	21.4, 190
2	.41	.21	.11
	.068, .015	1.3, 2.4	.12, 31.5
3	.61	.31	.16
	.35, .015	.09, .09	.23, 9.5
4	.81	.41	.21
	.19, .33	.028, .30	.13, 3.
6	1.21	.61	.31
	.06, .003	.035, .12	.01, .23
8	1.65	.81	.41
	.02, .022	.09, .19	.037, .041

Table 4

PER CENT ERROR OF THE INPUT IMPEDANCE OF A 2λ DIPOLE
USING PARTIAL INTEGRATION AS COMPARED TO COMPLETE
INTEGRATION

structures with very asymmetric feeds. No exact guidelines have been established; therefore, it is probably best to experiment with any given class of problems if a minimum value of KH is sought. The default value for the KH parameter in the AMPJ code is one wavelength.

4.0 DESCRIPTION OF COMPUTER CODE CHANGES

The following subroutines have been changed to implement the optional junction interpolation and approximate matrix filling:

CABC
CMSET
DATAGN
FACTR
INTG
JMELS
LFACTR
MAIN
SOLVES
TRIO

In addition the variable JMAX has been added to common block/DATA/ throughout the program. JMAX is the total number of junctions at which the new interpolation method is used.

The matrix filled by subroutine CMSET consists of, first, segment field equations in the order of segment numbers and then equations for the current derivatives from equation (46). For a structure with symmetry the field equations for the first section are followed by the current derivative equations for that section and the equations continue in that order through all symmetric sections. Thus, for a structure with two symmetric sections the matrix equation has the form

$$\begin{bmatrix}
 A_1 & B_1 & A_2 & B_2 \\
 C_1 & D_1 & C_2 & D_2 \\
 A_2 & B_2 & A_1 & B_1 \\
 C_2 & D_2 & C_1 & D_1
 \end{bmatrix}
 \begin{bmatrix}
 I_1 \\
 \alpha_1 \\
 I_2 \\
 \alpha_2
 \end{bmatrix}
 =
 \begin{bmatrix}
 E_1 \\
 0 \\
 E_2 \\
 0
 \end{bmatrix}$$

where I_1 and α_1 represent column vectors of the unknown currents and current derivatives, respectively, on the first section. Only the upper half of the matrix, representing equations for the first section, is stored and is stored in transposed form as in program AMP. Subroutine ETMNS which fills the right hand side vector has not been modified and hence fills the applied field values in consecutive locations. Subroutine SOLVES, however, has been modified to insert zeros for the current derivative equations and reposition the applied field values for structures with symmetry before solving the matrix equation.

Some of the common block lengths have been changed from those in program AMP. The maximum number of segments is 800 in AMPJ although this is also the upper limit for the sum of the number of segments and the number of junctions at which the optional interpolation is used. Also, the area in core for storage of the interaction matrix has been increased to 10000 complex numbers. This allows structures with up to 100 unknowns (segments plus junctions with new interpolation method) to run in core. In this form the program requires approximately 240000 words of storage to load on a CDC 6000 series computer when compiled with the FTN compiler.

The following are brief descriptions of the changes to the modified subroutines. Lists of these routines are included at the end of this section. Since the routines have not been sequence numbered the changes can be located by the gaps in the old sequence numbers. References to statement labels refers to the labels in the left hand column of the list.

CABC

This routine computes the constants A_j , B_j and C_j for equation (1) for either the old or new interpolation method. The statements down to label 15 +1 set CLO, CLL and CLY as follows:

$$CLO = K_j^- \text{ or } \alpha^-$$

$$CLL = I_j$$

$$CLY = K_j^+ \text{ or } \alpha^+$$

A connection number less than -90000 for a segment end indicates the new interpolation method is used at that end requiring α^- or α^+ . The statements from label 16 through 21 compute $AX = A_j$, $BX = B_j$ and $CX = C_j$. Statements labeled 16 + 2 through 16 + 5 evaluate equations (5) and (6); 17 + 1 through 17 + 4 evaluate equations (24) and (25); 18 through 18 + 3 evaluate equations (17) and (18); and 19 through 19 + 2 evaluate equations (31) and (32). For each case statement 20 evaluates $C_j = I_j - A_j$. Finally from statement 20 + 1 through 21 the real and imaginary parts of the constants are stored in arrays.

CMSET

Sequence number
references

CM19.1+2 : JSEQ(J) = matrix row for segment J
CM19.1+2 : JJEQ(J) = matrix row for current derivative
at junction J.
CM122.1 : Branch to section for approximate matrix fill.
CM127+1 :

$$CE1 = \int_{-\Delta_j}^{\Delta_j} G_i(s) X_j(s) ds$$

$$CE2 = \int_{-\Delta_j}^{\Delta_j} G_i(s) Y_j(s) ds$$

$$CE3 = \int_{-\Delta_j}^{\Delta_j} G_i(s) Z_j(s) ds$$

CM127 + 11 to
CM 127 + 13 : expressions (37), (38) and (39) are evaluated
label 24 + 1 to
label 24 + 3 : expressions (34), (35) and (36) are evaluated
label 26 to
label 26 + 3 : equations (40), (41) and (42) are evaluated. In
the above three cases the contributions to α
columns are entered into the matrix. Other contri-
butions are entered in the following code.

label 27 to
 label 28 : fill matrix elements for - end of segment (currents
 in K_j^-)
 label 29 : fill matrix element for I_j
 label 29 + 1
 to label 30 : fill matrix elements for + end of segment (currents
 in K_j^+)
 CM 144.2 to
 CM145 : Approximate matrix fill section. Equations (47)
 and (48) are evaluated.
 label 18 + 1
 to label 66 : Equation (46) is evaluated for each segment.
 JCAS corresponds to the cases 1, 2, 3 and 4 in
 the equation.

DATAGN

The coding from statement label 9 + 2 through the end of this routine sets the connection numbers for segment ends at which the new interpolation will be used. The JX or JE data cards are read at statement 111. Statements 21 + 1 through 207 set the connection number for a segment end specified by a JX card and for all other segments connected to that segment end. Statements 208 through 210 search for all multiple junctions and reset the connection numbers for the new interpolation. The latter section is entered when a blank JX card occurs first or when there is no JX card but only a JE card.

The variable JMAX is used to count the number of junctions at which the new interpolation is specified. The connection numbers for all segments connected to junction number JMAX are set to $-(90000 + JMAX)$. On exit from the routine, JMAX is left as the final number of junctions with the new interpolation and passed through common/DATA/ to other routines.

FACTR

Minor modifications have been made to FACTR following sequence number FA31 and at FA59 to use temporary variables to avoid unnecessary evaluations of subscript references.

INTG

Statements added following IG42 evaluate X, Y and Z of equations (43), (44) and (45) and store them in XM, YM, and ZM respectively.

JMELS

The calculations of the matrix row indices JPJ and JMJ have been changed. While JP(J) and JM(J) represent segment numbers JPJ and JMJ are the locations in the matrix corresponding to these segments, taking into account the additional matrix rows for current derivative unknowns.

LFACTR

Minor modifications have been made to LFACTR at LF58 and LF92 to use temporary variables to avoid unnecessary evaluations of subscript references.

MAIN

Sequence number
references

MA64 to MA65 :	JPMAX = number of junctions with new interpolation in one symmetric section
	NEQ = total number of unknowns
	NPEQ = number of unknowns for one symmetric section.
MA139 + 1 :	RKH = default value for separation distance at which matrix filling changes over to approx- imate form.
MA188 to MA189 :	Set new value for RKH

SOLVES

Statements between sequence number SS11 and SS13 insert zeros in the B vector for the right hand side of the matrix equation in locations corresponding to the current derivative equations. For structures having symmetry the applied field values are relocated, using Y as scratch storage, to make room for the zeros within the vector.

Statements between sequence numbers SS67 and SS68 rearrange the solution vector for the case of a symmetric structure which uses the new interpolation on some junctions. The solution vector at SS67 consists of the currents for the first symmetric section followed by the current derivatives for junctions on the first section, then currents for the next section, and continues in this order through all sections. These statements put the currents in consecutive locations so that I_j is in location j , with the current derivatives in consecutive locations following the last current value.

TRIO

The statements following TR12 and TR18 have been added so that DIL or DIK are set to Δ_j for new interpolation on the - or + segment end respectively.

Lists of the changed routines follow.


```

IF (NEQ.NE.NPEQ) GO TO 4
IF (INT.EQ.1) GO TO 7
NCOL=NPEQ
ICASE=1
GO TO 11
7 NCOL=2*NPRLK
ICASE=1
GO TO 11
8 IF (INT.EQ.1) GO TO 9
NCOL=NPEQ
NCOLS=NPEQ
ICASE=2
GO TO 11
9 CALL FLOCK (NRLSY=NOSYM,NLSYM,INESRV,NPEQ,NPEQ,INT)
NCOL=2*NPRLK
IF (INT.EQ.1) GO TO 10
NCOLS=NPEQ
ICASE=4
GO TO 11
10 NCOLS=2*NPSYM
ICASE=4
11 CONTINUE
NRLOKX=NBLOKS
NPRLKX=NPRLK
NLAST=NLAST
NRQW=NROW
NCOLX=NCOL
PRINT 135
C
C FILE PREPARATION FOR OUT-OF-CORE MATRIX SOLUTION. FILES REWOUND
C AND ENDFILE WRITTEN. AND TESTING FOR RESTART
C
IF (ISTART.EQ.0) GO TO 12
CALL UNCAT
GO TO 14
12 IF (ICASE.LT.3) GO TO 14
DO 13 I=1,7
NUNIT=ITAP(I)
REWIND NUNIT
END FILE NUNIT
REWIND NUNIT
13 CONTINUE
14 CONTINUE
C DEFAULT VALUES FOR INPUT PARAMETERS AND FLAGS
IGO=1
FMHZ=300.
FMHZ=300.
NFRQ=1
PKM=1.
NLOAD=0
KSYMP=1
IXTYP=0
NET=0
NRADL=0
NEAD=1
IPTFLG=-2
IFAR=1
ZPAT=CMPLX(1.,0.)
IPERF=1
IPED=0
C
C MAIN INPUT SECTION - STANDARD HEAD STATEMENT. - JUMPS TO APPRO-
C PRIATE SECTION FOR SPECIFIC PARAMETER SET UP.
C
15 READ 176. AIN,ITMP1,ITMP2,ITMP3,ITMP4,TMP1,TMP2,TMP3,TMP4,TMP5,TMP6
IP6
MPCNT=MPCNT+1
PRINT 137. MPCNT,AIN,ITMP1,ITMP2,ITMP3,ITMP4,TMP1,TMP2,TMP3,TMP4,
1 TMP5,TMP6
IF (AIN.EQ.ATST(2)) GO TO 17
IF (AIN.EQ.ATST(3)) GO TO 18
IF (AIN.EQ.ATST(4)) GO TO 22
IF (AIN.EQ.ATST(5)) GO TO 25
IF (AIN.EQ.ATST(6)) GO TO 29
IF (AIN.EQ.ATST(14)) GO TO 29
IF (AIN.EQ.ATST(15)) GO TO 32
IF (AIN.EQ.ATST(7)) GO TO 38
IF (AIN.EQ.ATST(8)) GO TO 33
IF (AIN.EQ.ATST(9)) GO TO 35
IF (AIN.EQ.ATST(10)) GO TO 37
IF (AIN.EQ.ATST(17)) GO TO 201
IF (AIN.EQ.ATST(12)) GO TO 1
IF (AIN.EQ.ATST(13)) GO TO 16
IF (ITMP1.NE.0) CALL CATLOG
STOP
16 PRINT 138
STOP
C
C FREQUENCY PARAMETERS
C
17 IFRQ=ITMP1
NFRQ=ITMP2
IF (NFRQ.EQ.0) NFRQ=1
FMHZ=TMP1
DELFRO=TMP2
IF (IPED.EQ.1) ZPNORM=0.
IGO=1
IFLOW=2
GO TO 15

```

NA 91
 NA 92
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 NA 187
 NA 188

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0000	MATRIX INTEGRATION LIMIT	
221	IK=TMP1	NA 149
	IGD=1	NA 190
	IFLOW=2	NA 191
	GO TO 15	NA 192
0000	LOADING PARAMETERS	NA 193
14	IF (IFLOW.EQ.1) GO TO 19	NA 194
	NLOAD=0	NA 195
	IFLOW=3	NA 196
	IF (IGD.GT.2) IGD=2	NA 197
	IF (ITMP1.EQ.(-1)) GO TO 15	NA 198
19	NLOAD=NLOAD+1	NA 199
	IF (NLOAD.LE.LOADM) GO TO 20	NA 200
	PRINT 139	NA 201
	STOP	NA 202
20	LOT*(NLOAD)=ITMP1	NA 203
	LOTAG(NLOAD)=ITMP2	NA 204
	IF (ITMP4.EQ.0) ITMP4=ITMP3	NA 205
	LOTAG(NLOAD)=ITMP3	NA 206
	LOTAG(NLOAD)=ITMP4	NA 207
	IF (ITMP4.GE.ITMP3) GO TO 21	NA 208
	PRINT 140, NLOAD,ITMP3,ITMP4	NA 209
	PRINT 144, ISECN(1)	NA 210
	STOP	NA 211
21	ZLP(NLOAD)=TMP1	NA 212
	ZLI(NLOAD)=TMP2	NA 213
	ZLC(NLOAD)=TMP3	NA 214
	GO TO 15	NA 215
0000	GROUND PARAMETERS UNDER THE ANTENNA	NA 216
22	IFLOW=4	NA 217
	IF (IGD.GT.2) IGD=2	NA 218
	IF (ITMP1.NE.(-1)) GO TO 23	NA 219
	*SYMP=1	NA 220
	*RADL=1	NA 221
	GO TO 15	NA 222
23	IPEDF=ITMP1	NA 223
	*RADL=ITMP2	NA 224
	*SYMP=2	NA 225
	EPSD=TMP1	NA 226
	SIG=TMP2	NA 227
	IF (*RADL.EQ.0) GO TO 24	NA 228
	SCRWLT=TMP3	NA 229
	SCRWRT=TMP4	NA 230
	GO TO 15	NA 231
24	EPSR2=TMP3	NA 232
	SIG2=TMP4	NA 233
	CLT=TMP5	NA 234
	CHT=TMP6	NA 235
	GO TO 15	NA 236
0000	EXCITATION PARAMETERS	NA 237
25	IF (IFLOW.EQ.5) GO TO 26	NA 238
	IPDFLO=-2	NA 239
	NSANT=0	NA 240
	IPED=0	NA 241
	IFLOW=5	NA 242
	IF (IGD.GT.3) IGD=3	NA 243
26	MASYM=ITMP4/10	NA 244
	IF (ITMP1.GT.0) GO TO 28	NA 245
	IXTP=ITMP1	NA 246
	NTSOL=0	NA 247
	NSANT=NSANT+1	NA 248
	IF (NSANT.LE.NSMAX) GO TO 27	NA 249
	PRINT 1-1	NA 250
	STOP	NA 251
27	ISANT(NSANT)=ISFNO(ITMP2+ITMP3)	NA 252
	IPED=ITMP4-MASYM*10	NA 253
	VSANT(NSANT)=CMPLX(TMP1,TMP2)	NA 254
	IF (CABS(VSANT(NSANT)).LT.1.E-20) VSANT(NSANT)=(1.,0.)	NA 255
	ZNORM=TMP3	NA 256
	IF (IPED.EQ.1.AND.7*ZNORM.GT.0) IPED=2	NA 257
	GO TO 15	NA 258
28	IF (IXTP.EQ.0) NTSOL=0	NA 259
	IXTP=ITMP1	NA 260
	NT=IXTP2	NA 261
	XPR=IXTP3	NA 262
	XPR2=TMP2	NA 263
	XPR3=TMP3	NA 264
	XPR4=TMP4	NA 265
	XPR5=TMP5	NA 266
	XPR6=TMP6	NA 267
	VSANT=0	NA 268
	THEYIS=XPR1	NA 269
	THEYIS=XPR2	NA 270
	GO TO 15	NA 271
0000	NETWORK PARAMETERS	NA 272
29	IF (IFLOW.EQ.4) GO TO 30	NA 273
	NET=0	NA 274
	NTSOL=0	NA 275
		NA 276
		NA 277
		NA 278
		NA 279
		NA 280

	IFLOW=4	NA 281
	IF (ISQ.GT.3) IGO=1	NA 282
	IF (ITMP2.EQ.1-1) GO TO 15	NA 283
30	NET=NET+1	NA 284
	IF (NET.LE.NETMX) GO TO 31	NA 285
	PRINT 142	NA 286
	STOP	NA 287
31	NTYP(NET)=2	NA 288
	IF (AIN.EQ.ATST(5)) NTYP(NET)=1	NA 289
	ISFG1(NET)=ISFGNO(ITMP1,ITMP2)	NA 290
	ISFG2(NET)=ISFGNO(ITMP3,ITMP4)	NA 291
	Y11P(NET)=TMP1	NA 292
	Y111(NET)=TMP2	NA 293
	Y12P(NET)=TMP3	NA 294
	Y121(NET)=TMP4	NA 295
	Y22P(NET)=TMP5	NA 296
	Y221(NET)=TMP4	NA 297
	IF (NTYP(NET).EQ.1.OR.TMP1.GT.0.) GO TO 15	NA 298
	NTYP(NET)=3	NA 299
	Y11R(NET)=TMP1	NA 300
	GO TO 15	NA 301
C		NA 302
C	PRINT CONTROL	NA 303
C		NA 304
32	IPFLG=ITMP1	NA 305
	IPTAG=ITMP2	NA 306
	IPTAGF=ITMP3	NA 307
	IPTAGT=ITMP4	NA 308
	IF (ITMP4.EQ.0) IPTAGT=IPTAGF	NA 309
	GO TO 15	NA 310
C		NA 311
C	NEAR FIELD CALCULATION PARAMETERS	NA 312
C		NA 313
33	IF (.NOT.(IFLOW.EQ.8.AND.NFRQ.NE.1)) GO TO 34	NA 314
	PRINT 143	NA 315
	PRINT 144, ISECN(1)	NA 316
34	NRX=ITMP1	NA 317
	NRX=ITMP2	NA 318
	NRX=ITMP3	NA 319
	NRZ=ITMP4	NA 320
	XNR=TMP1	NA 321
	YNR=TMP2	NA 322
	ZNR=TMP3	NA 323
	DXNR=TMP4	NA 324
	DYNR=TMP5	NA 325
	DZNR=TMP6	NA 326
	IFLOW=8	NA 327
	IF (NFRQ.NE.1) GO TO 15	NA 328
	GO TO (42,47,54,72,73), IGO	NA 329
C		NA 330
C	GROUND REPRESENTATION	NA 331
C		NA 332
35	IF (.NOT.(IFLOW.EQ.9.AND.NFRQ.NE.1)) GO TO 36	NA 333
	PRINT 144, ISECN(2)	NA 334
36	EPSR2=TMP1	NA 335
	SIG2=TMP2	NA 336
	CLT=TMP3	NA 337
	CHT=TMP4	NA 338
	IFLOW=9	NA 339
	GO TO 15	NA 340
C		NA 341
C	STANDARD OBSERVATION ANGLE PARAMETERS	NA 342
C		NA 343
37	IFAR=ITMP1	NA 344
	NTM=ITMP2	NA 345
	NPM=ITMP3	NA 346
	IF (NTM.EQ.0) NTM=1	NA 347
	IF (NPM.EQ.0) NPM=1	NA 348
	IPD=ITMP4/10	NA 349
	IAPD=ITMP4-IPD*10	NA 350
	INOR=IPD/10	NA 351
	IPD=IPD-INOR*10	NA 352
	IAX=INOR/10	NA 353
	INOR=INOR-IAX*10	NA 354
	IF (IAX.NE.0) IAX=1	NA 355
	IF (IPD.NE.0) IPD=1	NA 356
	IF (NTM.LT.2.OR.NPM.LT.2) IAPD=0	NA 357
	IF (IFAR.EQ.1) IAPD=0	NA 358
	THETS=TMP1	NA 359
	PHIS=TMP2	NA 360
	DTM=TMP3	NA 361
	OPM=TMP4	NA 362
	RFID=TMP5	NA 363
	GNOR=TMP6	NA 364
	IFLOW=10	NA 365
	GO TO (42,47,54,72,80), IGO	NA 366
C		NA 367
C	EXECUTE CARD - CALC. INCLUDING RADIATED FIELDS	NA 368
C		NA 369
38	IF (IFLOW.EQ.10.AND.ITMP1.EQ.0) GO TO 15	NA 370
	IF (NFRQ.EQ.1.AND.ITMP1.EQ.0.AND.IFLOW.GT.7) GO TO 15	NA 371
	IF (ITMP1.NE.0) GO TO 40	NA 372
	IF (IFLOW.GT.7) GO TO 19	NA 373
	IFLOW=7	NA 374
	GO TO 41	NA 375
39	IFLOW=11	NA 376
	GO TO 41	NA 377
40	IFAR=0	NA 378
	RFID=0.	NA 379

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	IPD=0	MA 380
	IAV=0	MA 381
	INCR=0	MA 382
	IAK=0	MA 383
	NT=0	MA 384
	NR=0	MA 385
	THET=0	MA 386
	PHIS=0	MA 387
	DT=0	MA 388
	DP=0	MA 389
	IF (ITW=1.EQ.2) PHIS=90.	MA 390
	IF (ITW=1.EQ.3) GO TO 41	MA 391
	ND=0	MA 392
	DP=0	MA 393
41	GO TO (42,47,54,72,80), IGO	MA 394
C	END OF THE MAIN INPUT SECTION	MA 395
C	BEGINNING OF THE FREQUENCY DO LOOP	MA 396
C		MA 397
42	W=7	MA 398
43	IF (W=7.EQ.1) GO TO 45	MA 399
	IF (W=7.EQ.2) GO TO 44	MA 400
	FW=2*W-2*CELEPQ	MA 401
	GO TO 45	MA 402
44	FW=2*W-2*CELEPQ	MA 403
45	FW=FW+FW*75	MA 404
	WLAN=300./FW*7	MA 405
	PRINT 145, FW*7, WLAN	MA 406
	PRINT 147, SKM	MA 407
C	FREQUENCY SCALING OF GEOMETRIC PARAMETERS	MA 408
	FW=35*FW*7	MA 409
	DO=100./FW	MA 410
	W=100./FW	MA 411
	V=100./FW	MA 412
	Z=100./FW	MA 413
	S=100./FW	MA 414
45	S=100./FW	MA 415
	S=100./FW	MA 416
C	STRUCTURE SEGMENT LOADING	MA 417
47	PRINT 146	MA 418
	IF (WLOAD.NE.0) CALL LOAD (LDTP,LDTAG,LDTAGF,LDTAGT,ZL,ZLI,ZLC,N	MA 419
	LOAD)	MA 420
	IF (WLOAD.EQ.0) PRINT 147	MA 421
C	GROUND PARAMETER	MA 422
	PRINT 148	MA 423
	IF (KSYMP.EQ.1) GO TO 50	MA 424
	IF (IDEPF.EQ.1) GO TO 49	MA 425
	ZP=1+SCRT(1./((EPSR-SIG*WLAN*59.92*FJ)))	MA 426
	IF (WADL.EQ.0) GO TO 48	MA 427
	SCRW=SCRWLT/WLAN	MA 428
	SCRW=SCRWLT/WLAN	MA 429
	PRINT 179, NRADL,SCRWLT,SCRWRT	MA 430
	PRINT 149	MA 431
48	PRINT 150, EPSR,SIG	MA 432
	GO TO 51	MA 433
49	PRINT 151	MA 434
	GO TO 51	MA 435
50	PRINT 152	MA 436
51	CONTINUE	MA 437
C		MA 438
C	STRUCTURE MATRIX SET UP	MA 439
C		MA 440
	IF (ISTART.NE.0) GO TO 52	MA 441
	IC1=0	MA 442
	IC2=IC1	MA 443
	IC3=IC1	MA 444
52	NROW=NROW	MA 445
	NCOL=NCOL	MA 446
	NBLOC=NBLOC	MA 447
	NBLOC=NBLOC	MA 448
	NBLOC=NBLOC	MA 449
	NBLOC=NBLOC	MA 450
	CALL SECOND (TIM1)	MA 451
	CALL CWRT(NROW,NCOL,CM,NLOAD,PKH)	MA 452
	CALL SECOND (TIM2)	MA 453
	TIM=TIM2-TIM1	MA 454
C		MA 455
C	MATRIX FACTORIZATION	MA 456
C		MA 457
	CALL FACTPS(NROW,NP,CM,IP,IX,NROW,NCOL,NCOLS,IPSY)	MA 458
	ISTART=0	MA 459
	IF (ICASE.LE.1) GO TO 53	MA 460
	NROW=NROW	MA 461
	NCOL=NCOL	MA 462
53	CALL SECOND (TIM1)	MA 463
	TIM=TIM1-TIM2	MA 464
	PRINT 153, TIM,TIM2	MA 465
	INC=0	MA 466
	NT=0	MA 467
C		MA 468
C	EXCITATION SET UP (RIGHT HAND SIDE, -E INC.)	MA 469
54	NT=0	MA 470
	NROW=0	MA 471
	INC=0	MA 472
	NT=0	MA 473
	NT=0	MA 474
55	IF (ITW.EQ.0) GO TO 57	MA 475
	IF (ITW.LE.0.09,ITW.EQ.4) PRINT 154	MA 476
	TW=ITW*1000	MA 477
		MA 478

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TMP4=TA*XP4
IF (IXTYP.LE.3) GO TO 56
TMP1=XP01/WLAM
TMP2=XP02/WLAM
TMP3=XP03/WLAM
TMP4=XP04/WLAM
PRINT 156, XDP1,XP02,XP03,XP04,XP05,XP06
GO TO 57
56 TMP1=TA*XP01
TMP2=TA*XP02
TMP3=TA*XP03
TMP4=XP04
IF (IPTFLG.LE.0) PRINT 155, XDP1,XP02,XP03,XP04,XP05,XP06
57 CALL ETMNS (TMP1,TMP2,TMP3,TMP4,TMP5,TMP6,IXTYP,ISANT,VSANT,NSANT,
ICUR)
C
C MATRIX SOLVING (NETWK CALLS SOLVES)
C
IF (NET.EQ.0.OR.INC.GT.1) GO TO 61
PRINT 158
ITMP3=0
ITMP1=NTYP(1)
DO 60 I=1,2
IF (ITMP1.EQ.3) ITMP1=2
IF (ITMP1.EQ.2) PRINT 159
IF (ITMP1.EQ.1) PRINT 160
DO 59 J=1,NET
ITMP2=NTYP(J)
IF ((ITMP2/ITMP1).EQ.1) GO TO 59
ITMP3=ITMP2
GO TO 59
58 ITMP4=ISEG1(J)
ITMP5=ISEG2(J)
IF (ITMP2.GE.2.AND.Y111(J).LE.0) Y111(J)=WLAM*SQRT((X(ITMP5)-X(IT
IM4))**2+(Y(ITMP5)-Y(ITMP4))**2)/(Z(ITMP5)-Z(ITMP4))**2)
PRINT 157, ITAG(ITMP4),ITMP4,ITAG(ITMP5),ITMP5,Y111(J),Y111(J),
I Y12R(J),Y12I(J),Y22R(J),Y22I(J),PNET(2*ITMP2-1),PNET(2*ITMP2)
59 CONTINUE
IF (ITMP3.EQ.0) GO TO 61
ITMP1=ITMP3
CONTINUE
60 CONTINUE
61 CONTINUE
IF (INC.GT.1.AND.IPTFLG.GT.0) NOPRINT=1
CALL NETWK (ISEG1,ISEG2,Y111R,Y111I,Y12R,Y12I,Y22R,Y22I,NET,NTYP,ISA
INT,VSANT,NSANT,CM,[P,CUR,NP0W,NCOL,IX,PIN,PLOSNT,NPRINT,NASYM,ZPED
2,NTSOL,JPMAX)
NTSOL=1
IF (IPED.EQ.0) GO TO 62
ITMP1=MHZ*4*(MHZ-1)
IF (ITMP1.GT.(NORMF-3)) GO TO 62
FNORM(ITMP1)=REAL(7PE0)
FNORM(ITMP1+1)=A[MAG(7PE0)
FNORM(ITMP1+2)=CAHS(ZPED)
FNORM(ITMP1+3)=CANG(ZPED)
IF (IPED.EQ.2) GO TO 62
IF (FNORM(ITMP1+2).GT.ZPNORM) ZPNORM=FNORM(ITMP1+2)
62 CONTINUE
C
C PRINTING STRUCTURE CURRENTS
C
IF (IPTFLG.EQ.(-1)) GO TO 64
IF (IPTFLG.GT.0) GO TO 63
PRINT 161
PRINT 162
GO TO 64
63 IF (IPTFLG.EQ.3.OR.INC.GT.1) GO TO 64
PRINT 163, XPR3,MPOL(IXTYP),XDP6
64 PLOSS=0.
ITMP1=0
JUMP=IPTFLG+1
DO 70 I=1,N
CUR1=CUR(I)*WLAM
CHAG=CAHS(CUR1)
PH=CANG(CUR1)
IF (INLAD.EQ.0) GO TO 65
IF (IABS(REAL(7ADRAY(I))),LT.1,F-2) GO TO 65
PLOSS=PLOSS+.5*CHAG*CHAG*REAL(7ADRAY(I))*SI(I)
65 IF (JUMP) 69,70,66
66 IF (IPTAG.EQ.0) GO TO 67
IF (ITAG(I).NF.IPTAG) GO TO 70
67 ITMP1=ITMP1+1
IF (ITMP1.LT.IPTAGF.OR.ITMP1.GT.IPTAGT) GO TO 70
IF (IPTFLG.EQ.0) GO TO 69
IF (IPTFLG.LT.2.OR.INC.GT.NORMF) GO TO 68
FNORM(INC)=CHAG
ISAVE=I
68 IF (IPTFLG.NE.3) PRINT 164, XDP1,XP02,CHAG,PH,I
GO TO 70
69 PRINT 165, I,ITAG(I),X(I),Y(I),Z(I),SI(I),CUR1,CHAG,PH
70 CONTINUE
IF (IXTYP.NE.0) GO TO 71
TMP1=PIN-PLOSNT-PLOSS
TMP2=100.*TMP1/PIN
PRINT 166, PIN,TMP1,PLOSS,PLOSNT,TMP2
71 CONTINUE
IG0=4
IF (IFLOW.NE.7) GO TO 72
IF (IXTYP.GT.0.AND.IXTYP.LT.4) GO TO 114
IF (INPD0.NE.1) GO TO 121

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PRINT 135
GO TO 15
C
C
C
C
C
72 CALL CARC
107=5
C
C
C
C
C
73 NEAR FIELD CALCULATION
IF (NEAR.EQ.(-1)) GO TO 79
PRINT 147
FACT=ZNR-DZNR
DO 73 I=1,NPZ
ZNR=ZNR+DZNR
IF (NEAR.EQ.0) GO TO 74
CT=COOCTA*ZNR
ST=5*(TA*ZNR)
74 YNR=YNR-DNR
DO 74 J=1,NRY
YNR=YNR-DNR
IF (NEAR.EQ.0) GO TO 75
CPH=COOCTA*YNR
SPH=5*(TA*YNR)
75 XNR=XNR-DNR
DO 75 K=1,NRX
XNR=XNR-DNR
IF (NEAR.EQ.0) GO TO 76
XPR=XNR*STH*CPH
YPR=YNR*STH*SPH
ZPR=XNR*CTH
GO TO 77
76 XPR=XNR
YPR=YNR
ZPR=ZNR
77 TMP1=CCR/WLAM
TMP2=CCR/WLAM
TMP3=ZCR/WLAM
CALL NFELD (TMP1,TMP2,TMP3,EX,EY,EZ)
TMP1=CARS(EX)
TMP2=CARS(EY)
TMP3=CARS(EZ)
TMP4=CARS(XX)
TMP5=CARS(YY)
TMP6=CARS(ZZ)
PRINT 168, XPR,YPR,ZPR,TMP1,TMP2,TMP3,TMP4,TMP5,TMP6
78 CONTINUE
IF (NEAR.EQ.NF0) NEAR=-1
IF (NEAR.NE.1) GO TO 79
PRINT 135
GO TO 15
79 CONTINUE
C
C
C
C
C
80 STANDARD FAR FIELD CALCULATION
IF (IFAR.EQ.-1) GO TO 114
IF (IFAR.LT.2) GO TO A2
PRINT 169
IF (IFAR.LE.3) GO TO A1
PRINT 170, NPADL,SCR,LT,SCRRT
IF (IFAR.EQ.4) GO TO A2
A1 IF (IFAR.EQ.2.OR.IFAR.EQ.5) HCLIF=HPCOL(1)
IF (IFAR.EQ.3.OR.IFAR.EQ.5) HCLIF=HCIR
CL=CLT/WLAM
CH=CHT/WLAM
ZPAT12=CSORT(1./(EPSR2-SIG2*WLAM*59.92*FJ))
PRINT 171, HCLIF,CLT,CHT,EPSR2,SIG2
82 IF (IFAR.NE.1) GO TO A3
PRINT 175
GO TO A5
83 I=2*(PD-1)
J=I+1
ITMP1=2*JAX+1
ITMP2=ITMP1+J
PRINT 172
IF (PD.LT.1.E-20) GO TO A4
EXPR=ELM/PFLD
EXPR=ELM/WLAM
EXPA=-340.*(EXPA-AINT(EXPA))
PRINT 173, RFLD,EXRM,EXRA
PRINT 174, IGTPI,IGTPJ,IGAX(ITMP1),IGAX(ITMP2)
84 IF (ITYP.EQ.3) GO TO A7
85 IF (ITYP.EQ.4) GO TO A6
PRINT 175
GCON=4.*PI/(1.+XPR6*XDR6)
GCON=GCON
GO TO A8
86 PIN=394.51*(XPR6*XDR6*WLAM*WLAM)
87 GCON=WLAM*WLAM*2.*PI/(176.73*PIN)
PRIN=PIN-PL0SS-PL0SNT
GCON=GCON
IF (IDC.NE.0) GCON=GCON*PIN/PRAN
88 I=0
GMAX=-1.E10
PRINT 176
TMP1=GDW*TA
TMP2=5*GDH*TA
PHI=PHIS-DRH
DO 109 KPH=1,NPH

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NA 578
 NA 579
 NA 580
 NA 581
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 NA 671
 NA 672
 NA 673
 NA 674
 NA 675
 NA 676

	PHI=PHI+DPH	NA 617
	PHA=PHI+TA	NA 618
	THET=THET+DTM	NA 619
	DO 109 KTH=1,NTH	NA 620
	THET=THET+DTM	NA 621
	IF (KSYMP.EQ.2.AND.THET.GT.92.51.AND.(IFAR.NE.1)) GO TO 109	NA 622
	THA=THET+TA	NA 623
	IF (IFAR.EQ.1) GO TO 49	NA 624
	CALL FFLD (THA,PHA,ETA,EPH)	NA 625
	GO TO 40	NA 626
49	CALL GFLD (RFLD/HLAM,PHA,THET/HLAM,ETH,EPH,ERD,79*TI,KSYMP)	NA 627
	ERDM=CARS(ERD)	NA 628
90	EPHA=CANG(ERD)	NA 629
	ETHM2=DFAL(ETH*CONJG(ETH))	NA 630
	ETHM=SQRT(ETHM2)	NA 631
	ETHA=CANG(ETH)	NA 632
	EPHM2=CEAL(EPH*CONJG(EPH))	NA 633
	EPHM=SQRT(EPHM2)	NA 634
	EPHA=CANG(EPH)	NA 635
	IF (IFAR.EQ.1) GO TO 104	NA 636
C	ELLIPTICAL POLARIZATION CALC.	NA 637
	IF (ETHM2.GT.1.E-20.OR.EPHM2.GT.1.E-20) GO TO 41	NA 638
	TILTA=0.	NA 639
	EMAJR2=0.	NA 700
	EMINR2=0.	NA 701
	AXRAT=0.	NA 702
	ISENS=HOLK	NA 703
	GO TO 96	NA 704
91	DFA7=EDHA-ETHA	NA 705
	IF (EPHA.LT.0.) GO TO 92	NA 706
	DFAZ2=DFAZ-360.	NA 707
	GO TO 93	NA 708
92	DFAZ2=DFAZ+360.	NA 709
93	IF (ARH(DFAZ),GT.ARS(DFAZ2)) DFAZ=DFAZ2	NA 710
	CDFAZ=COS(DFAZ*TA)	NA 711
	TSTOR1=ETHM2-EPHM2	NA 712
	TSTOR2=2.*EPHM*ETHM*CDFAZ	NA 713
	TILTA=.5*ATGN2(TSTOR2,TSTOR1)	NA 714
	STILTA=SIN(TILTA)	NA 715
	TSTOR1=TSTOR1*STILTA*STILTA	NA 716
	TSTOR2=TSTOR2*STILTA*STILTA	NA 717
	EMAJR2=-TSTOR1-TSTOR2*ETHM2	NA 718
	EMINR2=TSTOR1-TSTOR2*EPHM2	NA 719
	IF (EMINR2.LT.0.) EMINR2=0.	NA 720
	AXRAT=SQRT(EMINR2/EMAJR2)	NA 721
	TILTA=TILTA*TD	NA 722
	IF (AXRAT.GT.1.E-5) GO TO 94	NA 723
	ISENS=HOL(1)	NA 724
	GO TO 96	NA 725
94	IF (DFA7.GT.0.) GO TO 95	NA 726
	ISENS=HOL(2)	NA 727
	GO TO 96	NA 728
95	ISENS=HOL(3)	NA 729
96	GMMJ=DR10(GCON*EMAJR2)	NA 730
	GMMN=DR10(GCON*EMINR2)	NA 731
	GMMV=DR10(GCON*ETHM2)	NA 732
	GMM=DR10(GCON*EPHM2)	NA 733
	GTOT=DR10(GCON*(ETHM2-EPHM2))	NA 734
	IF (INNR.LT.1) GO TO 103	NA 735
	I=1	NA 736
	IF (I.GT.NORMAX) GO TO 103	NA 737
	GO TO (97,98,99,100,101), INCO	NA 738
97	TSTOR1=GMMJ	NA 739
	GO TO 102	NA 740
98	TSTOR1=GMMN	NA 741
	GO TO 102	NA 742
99	TSTOR1=GMMV	NA 743
	GO TO 102	NA 744
100	TSTOR1=GMM	NA 745
	GO TO 102	NA 746
101	TSTOR1=GTOT	NA 747
102	GAIN(1)=TSTOR1	NA 748
	IF (TSTOR1.GT.GMAX) GMAX=TSTOR1	NA 749
103	IF (IAVP.EQ.0) GO TO 104	NA 750
	TSTOR1=GCON*(ETHM2-EPHM2)	NA 751
	TMP3=THA-TMP2	NA 752
	TMP4=THA-TMP2	NA 753
	IF (KTH.EQ.1) TMP3=THA	NA 754
	IF (KTH.EQ.NTH) TMP4=THA	NA 755
	DA=ARS(TMP1*(COS(TMP3)-COS(TMP4)))	NA 756
	IF (KPH.EQ.1.OR.KPH.EQ.NP-1) DA=.5*DA	NA 757
	PINT=PI*INT+TSTOR1*DA	NA 758
	IF (IAVP.EQ.2) GO TO 109	NA 759
104	IF (IAX.EQ.1) GO TO 105	NA 760
	TMP5=GMMJ	NA 761
	TMP6=GMMN	NA 762
	GO TO 106	NA 763
105	TMP5=GMMV	NA 764
	TMP6=GMM	NA 765
106	IF (IRFLD.LT.1.E-20) GO TO 107	NA 766
	ETHM=ETHM*ERDM	NA 767
	ETHA=ETHA*ERDM	NA 768
	EPHM=EPHM*ERDM	NA 769
	EPHA=EPHA*ERDM	NA 770
107	PRINT 176, THET,PHI,TMP5,TMP6,GTOT,AXRAT,TILTA,ISENS,ETHM,ETHA,	NA 771
	EPHM,EPHA	NA 772
	GO TO 109	NA 773
109	PRINT 177, RFLD,PHI,THET,ETHM,ETHA,EPHM,EPHA,ERDM,ERD	NA 774
	CONTINUE	NA 775

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IF (I1,P.E2,0) GO TO 110
TMP3=I-TETS*TA
TMP4=TMP3*DTM*TA*FLOAT(NTM-1)
TMP5=ARS(OPH*TA*FLOAT(NPH-1))*(COS(TMP3)-COS(TMP4))
PINT=PINT/TMP3
TMP3=TMP3/P1
PRINT 178, PINT,TMP3
110 IF (INCR.EQ.0) GO TO 114
IF (ARS(GNOR).GT.1.E-20) GNAX=GNOR
ITMP1=(INOR-1)*2+1
ITMP2=ITMP1+1
PRINT 179, IGNTP(ITMP1),IGNTP(ITMP2),GNAX
ITMP2=GNOR*NTM
IF (ITMP2.GT.NORMAX) ITMP2=NORMAX
ITMP1=(ITMP2+2)/3
ITMP2=ITMP1*3-ITMP2
ITMP3=ITMP1
ITMP4=2*ITMP1
IF (ITMP2.EQ.2) ITMP4=ITMP4-1
DO 111 I=1,ITMP1
ITMP3=ITMP3+1
ITMP4=ITMP4+1
J=(I-1)/NTM
TMP1=TETS*FLOAT(I-J*NTM-1)*DTM
TMP2=P-TS*FLOAT(J)*OPH
J=(ITMP3-1)/NTM
TMP3=TETS*FLOAT(ITMP3-J*NTM-1)*DTM
TMP4=P-TS*FLOAT(J)*OPH
J=(ITMP4-1)/NTM
TMP5=TETS*FLOAT(ITMP4-J*NTM-1)*DTM
TMP6=P-TS*FLOAT(J)*OPH
TSTOR1=GAIN(I)-GNAX
IF (I.EQ.ITMP1.AND.ITMP2.NE.0) GO TO 112
TSTOR2=GAIN(ITMP3)-GNAX
PINT=GAIN(ITMP4)-GNAX
111 PRINT 180, TMP1,TMP2,TSTOR1,TMP3,TMP4,TSTOR2,TMP5,TMP6,PINT
GO TO 114
112 IF (ITMP2.EQ.2) GO TO 113
TSTOR2=GAIN(ITMP3)-GNAX
PRINT 180, TMP1,TMP2,TSTOR1,TMP3,TMP4,TSTOR2
GO TO 114
113 PRINT 180, TMP1,TMP2,TSTOR1
114 IF (ITYP.EQ.0.OR.IXTP.EQ.4) GO TO 120
NTM=IC*NTM*IC+1
INC=INC+1
XPR1=XPR1+XPR4
IF (NTM=IC.LE.NTH1) GO TO 55
NTM=IC+1
XPR1=TETS*
XPR2=XPR2+XPR5
NP=IC*NP*IC+1
IF (NP=IC.LE.NPM1) GO TO 55
NP=IC+1
XPR2=XPR2+ISS
IF (IPTFLG.LT.2) GO TO 120
ITMP1=NTM*NP*IC
IF (ITMP1.LE.NORMF) GO TO 115
ITMP1=XPR2
PRINT 181
TMP1=F4ORM(I)
DO 115 J=2,ITMP1
IF (F4ORM(J).GT.TMP1) TMP1=F4ORM(J)
115 CONTINUE
PRINT 182, TMP1,XPR3,MPOL(IXTP),XPR4,ISS*VE
DO 116 J=1,NPM1
ITMP2=NTM*(J-1)
DO 117 I=1,NTM1
ITMP3=I+ITMP2
IF (ITMP3.GT.ITMP1) GO TO 118
TMP2=F4ORM(ITMP3)/TMP1
TMP3=OR20(ITMP2)
PRINT 183, XPR1,XPR2,TMP3,TMP2
XPR1=XPR1+XPR4
117 CONTINUE
118 XPR1=TETS*
XPR2=XPR2+XPR5
119 CONTINUE
XPR2=XPR2+ISS
120 IF (NM7.EQ.NFRQ) IFAR=-1
IF (NFRQ.NE.1) GO TO 121
PRINT 135
GO TO 15
121 NM2=NM2+1
IF (NM7.LE.NFRQ) GO TO 43
IF (IPED.EQ.0) GO TO 124
PRINT 184, ISANT(NSANT),ZPNORM
ITMP1=NFRQ
IF (ITMP1.LE.(NORMF/4)) GO TO 122
ITMP1=XPR2/4
PRINT 185
122 IF (IFRQ.EQ.0) TMP1=FNMZ-(NFRQ-1)*DELFRQ
IF (IFRQ.EQ.1) TMP1=FNMZ/(DELFRQ*(NFRQ-1))
DO 123 I=1,ITMP1
ITMP2=I+I-1
TMP2=F4ORM(ITMP2)/ZPNORM
TMP3=F4ORM(ITMP2+1)/ZPNORM
TMP4=F4ORM(ITMP2+2)/ZPNORM
TMP5=F4ORM(ITMP2+3)
PRINT 186, TMP1,F4ORM(ITMP2),F4ORM(ITMP2+1),F4ORM(ITMP2+2),

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1 ENORM=(TMP2*3)+TMP2+TMP3+TMP4+TMP5
IF (IFRQ.EQ.0) TMP1=TMP1*DFLFRQ
IF (IFRQ.EQ.1) TMP1=TMP1*DFLFRQ
123 CONTINUE
PRINT 135
124 CONTINUE
NFRQ=1
NM7=1
GO TO 15

C
125 FORMAT (A2,13A6)
126 FORMAT (1M1)
127 FORMAT (////.33X,30M*****.////.34X,24MANTEN
INA MODELING PROGRAM.////.33X,30M*****
128 FORMAT (////.37X,24M- - - COMMENTS - - -)
129 FORMAT (25X,13A6)
130 FORMAT (////.10X,34MINCORRECT LABEL FOR A COMMENT CARD)
131 FORMAT (////.33X,31M- - - SEGMENTATION DATA - - -)
1 21MCOORDINATES IN METERS.////.25X.
2 50M1- AND 1- INDICATE THE SEGMENTS BEFORE AND AFTER 1-//
132 FORMAT (2X,4HSEG.,3X,26MCOORDINATES OF SEG. CENTER,5X,4HVEG.,
1 5X,14MORIENTATION ANGLES,4X,4HWE-E.,15-CONNECTION DATA,3X.
2 3MTAG.,2X,3MNO.,7X,14M9X,1M7,9X,1-2,7X,4HLENGTH,5X,5HSHALPHA.
3 5X,4HRETA,6X,6HRAIDUS,4X,2MI-.3X,1-1,4X,2-1-.4X,3MNO.)
133 FORMAT (1X,15.4F10.5,1X,3F10.5,1X,315.2X,15)
134 FORMAT (19H SEGMENT DATA ERROR)
135 FORMAT (////)
136 FORMAT (A2,13.315.6E10.3)
137 FORMAT (1X, 19M***** DATA CARD NO.,13.3X,12.1X,13.3(1X,15).
1 6(1X,12.5))
138 FORMAT (////.10X,45HFAULTY DATA CARD LABEL AFTER GEOMETRY SECTION)
139 FORMAT (////.10X,44HNUMBER OF LOADING CARDS EXCEEDS STORAGE ALLOTT
IED)
140 FORMAT (////.10X,31HDATA FAULT ON LOADING CARD NO.,15.5X,11HITAG
1STEP1=15.29M IS GREATER THAN ITAG STEP2=15)
141 FORMAT (////.10X,51HNUMBER OF EXCITATION CARDS EXCEEDS STORAGE ALL
IOTTED)
142 FORMAT (////.10X,44HNUMBER OF NFA00K CARDS EXCEEDS STORAGE ALLOTT
IED)
143 FORMAT (////.10X, 79MWHEN MULTIPLE FREQUENCIES ARE REQUESTED, ONLY
1 ONE NEAR FIELD CARD CAN BE USED - - - 10X,22HLAST CARD READ IS USED
2)
144 FORMAT (10X,25HSEE USERS MANUAL SECTION 14)
145 FORMAT (////.33X,33M- - - - FREQUENCY - - - - -)
1FREQUENCY=E11.4.4M NM7,36X,11H3VELENGTH=E11.4.7M METERS)
146 FORMAT (////.30X,40M- - - STRUCTURE IMPEDANCE LOADING - - -)
147 FORMAT (/ .35X,28HTHIS STRUCTURE IS NOT LOADED)
148 FORMAT (////.34X,31M- - - ANTENNA ENVIRONMENT - - -)
149 FORMAT (40X,21HMOIUM UNDER SCREEN -)
150 FORMAT (40X,27HRELATIVE DIELECTRIC CONST.=F7.3,40X,13HCONDUCTI
VITY=F10.3,11M NMOS/METER)
151 FORMAT ( 42X,14HPERFECT GROUND)
152 FORMAT ( 44X,10HFREE SPACE)
153 FORMAT (////.32X,25M- - - MATRIX TIMING - - -)
1 15H SEC., FACTOR=F4.3.5H SEC.)
154 FORMAT (////.40X,22M- - - EXCITATION - - -)
155 FORMAT (/4X,10HPLANE WAVE,4X,4HMTETA=F7.2,11M DEG. PHI=F7.2,
1 11M DEG. ETA=F7.2,13M DEG. TYPE =A6,15M. AXIAL RATIO=F6.3)
156 FORMAT (/31X,17HPOSITION (METERS),14X,14HORIENTATION (DEG)=F28X
1,14X,12X,1M7,12X,1M7,10X,5HSHALPHA,5X,4HRETA,4X,13HPOLE MOMENT,
2 4X,14HCURRENT SOURCE,1X,3(3X,F10.5),1X,2(3X,F7.2),4X,F8.3)
157 FORMAT (4X,4(15.1X),4(3X,E11.4),3X,46.32)
158 FORMAT (////.44X,24M- - - NETWORK DATA - - -)
159 FORMAT (/6X,18M- FROM - - TO -11X,17HTRANSMISSION LINE,15X,3
16M- - SHUNT ADMITTANCES (NMOS) - -14X,4HLINE,15X,21HITAG SEG
2. TAG SEG.,6X,9HIMPEDANCE,6X,6HLENGTH,12X,11M- END ONE -17X,11
3M- END TWO -12X,4HTYPE, 5X,21MNO. NO. NO.,9X,4HNOH
45X,4X,6HMETERS,9X, 4HREAL,10X,5HITAG,9X,4HREAL,10X,5HITAG,
160 FORMAT (/6X,8M- FROM -4X,6M- TO -26X,45M- - ADMITTANCE MATRI
1X ELEMENTS (NMOS) - -1X, 4X,21HITAG SEG. TAG SEG.,13X,9HIO
2NE,ONE),19X. 9H(CONF,TWO),19X,9H(10,10), 5X,21MNO. NO.
3 NO. NO.,4X,4HREAL,10X,5HITAG,9X,4HREAL,10X,5HITAG,9X,4HREAL
4. 10X,4HITAG.)
161 FORMAT (////.29X,33M- - CURRENTS AND LOCATION - - -)
1STANCES IN WAVELENGTHS)
162 FORMAT (/2X,4HSEG.,2X,3HITAG,4X,21HCOORD. OF SEG. CENTER,5X.
1 4HSEG.,12X,26M- - CURRENT (AMPS) - - -2X,34MNO.,3X,3MNO.,
2 5X,1M7,9X,1M7,9X,1M7,6X,6HLENGTH,5X,4HREAL,9X,5HITAG,7X,4HNOH,
3 8X,5HSHALPHA)
163 FORMAT (////.33X,40M- - RECEIVING PATTERN PARAMETERS - - -)
13X,4HMTETA=F7.2,8M DEGREES,4X,4HTYPE =14X,12HAXIAL RATIO,
2 F6.3, 11X,5HMTETA,5X,3HPI,10X,13M- CURRENT -9X,3HSEG,
3 -11X,5H(10EG),5X,5H(10EG),7X,9HMAGNITUDE,4X,5HSHALPHA,5X,3MNO.,
164 FORMAT (10X,21F7.2,3X),1X,E11.4,3X,F7.2,4X,15)
165 FORMAT (1X,215.3F9.4,F9.5,1X,3F12.4,F9.3)
166 FORMAT (////.40X,24M- - - POWER RUGET - - -)
1OWER =E11.4.6M WATTS, 4X,15HADIATED POWER=E11.4.6M WATTS,
2 4X,15HSTRUCTURE LOSS=E11.4.6M WATTS, 4X,15HNETWORK LOSS
3 =E11.4.6M WATTS,4X,15HEFFICIENCY = F7.2.8M PERCENT)
167 FORMAT (////.39X,23M- - NEAR FIELDS - - -)
1ON -21X 8M- EX -15X,4M- EX -15X,4M- EX -15X,4M- EX -15X,4M- EX
21M,10X,1M7,10X,1M7,10X, 9HMAGNITUDE,3X,5HSHALPHA,5X,9HMAGNITUDE,
33X,5HSHALPHA,6X,9HMAGNITUDE,7X,5HSHALPHA, 6X,6HMETERS,5X,6HMETERS
45X,5X,6HMETERS,8X,7HVOLTS/M,3X,7HDEGREES,4X,7HVOLTS/M,3X,7HDEGREES,
56X,7HVOLTS/M,7X,7HDEGREES)
168 FORMAT (2X,3(2X,F9.4),1X,3(3X,F11.4,2X,F7.2))
169 FORMAT (////.71X,39M- - FAR FIELD GROUND PARAMETERS - - -)
170 FORMAT (40X,25HRADIAL WIRE GROUND SCREEN,40X, 15.6M WTRES,4X

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104.12-WIRE LENGTH=.44.27 METERS.//.44X.12H.12F RADIUS=.E10.3.7H * NA 07-
217 171 172 173 174 175 176 177 178 179 180 181 182 183 184 185 186 187 188 189 190 191 192 193 194 195 196 197 198 199 200 201 202 203 204 205 206 207 208 209 210 211 212 213 214 215 216 217 218 219 220 221 222 223 224 225 226 227 228 229 230 231 232 233 234 235 236 237 238 239 240 241 242 243 244 245 246 247 248 249 250 251 252 253 254 255 256 257 258 259 260 261 262 263 264 265 266 267 268 269 270 271 272 273 274 275 276 277 278 279 280 281 282 283 284 285 286 287 288 289 290 291 292 293 294 295 296 297 298 299 300 301 302 303 304 305 306 307 308 309 310 311 312 313 314 315 316 317 318 319 320 321 322 323 324 325 326 327 328 329 330 331 332 333 334 335 336 337 338 339 340 341 342 343 344 345 346 347 348 349 350 351 352 353 354 355 356 357 358 359 360 361 362 363 364 365 366 367 368 369 370 371 372 373 374 375 376 377 378 379 380 381 382 383 384 385 386 387 388 389 390 391 392 393 394 395 396 397 398 399 400 401 402 403 404 405 406 407 408 409 410 411 412 413 414 415 416 417 418 419 420 421 422 423 424 425 426 427 428 429 430 431 432 433 434 435 436 437 438 439 440 441 442 443 444 445 446 447 448 449 450 451 452 453 454 455 456 457 458 459 460 461 462 463 464 465 466 467 468 469 470 471 472 473 474 475 476 477 478 479 480 481 482 483 484 485 486 487 488 489 490 491 492 493 494 495 496 497 498 499 500 501 502 503 504 505 506 507 508 509 510 511 512 513 514 515 516 517 518 519 520 521 522 523 524 525 526 527 528 529 530 531 532 533 534 535 536 537 538 539 540 541 542 543 544 545 546 547 548 549 550 551 552 553 554 555 556 557 558 559 560 561 562 563 564 565 566 567 568 569 570 571 572 573 574 575 576 577 578 579 580 581 582 583 584 585 586 587 588 589 590 591 592 593 594 595 596 597 598 599 600 601 602 603 604 605 606 607 608 609 610 611 612 613 614 615 616 617 618 619 620 621 622 623 624 625 626 627 628 629 630 631 632 633 634 635 636 637 638 639 640 641 642 643 644 645 646 647 648 649 650 651 652 653 654 655 656 657 658 659 660 661 662 663 664 665 666 667 668 669 670 671 672 673 674 675 676 677 678 679 680 681 682 683 684 685 686 687 688 689 690 691 692 693 694 695 696 697 698 699 700 701 702 703 704 705 706 707 708 709 710 711 712 713 714 715 716 717 718 719 720 721 722 723 724 725 726 727 728 729 730 731 732 733 734 735 736 737 738 739 740 741 742 743 744 745 746 747 748 749 750 751 752 753 754 755 756 757 758 759 760 761 762 763 764 765 766 767 768 769 770 771 772 773 774 775 776 777 778 779 780 781 782 783 784 785 786 787 788 789 790 791 792 793 794 795 796 797 798 799 800 801 802 803 804 805 806 807 808 809 810 811 812 813 814 815 816 817 818 819 820 821 822 823 824 825 826 827 828 829 830 831 832 833 834 835 836 837 838 839 840 841 842 843 844 845 846 847 848 849 850 851 852 853 854 855 856 857 858 859 860 861 862 863 864 865 866 867 868 869 870 871 872 873 874 875 876 877 878 879 880 881 882 883 884 885 886 887 888 889 890 891 892 893 894 895 896 897 898 899 900 901 902 903 904 905 906 907 908 909 910 911 912 913 914 915 916 917 918 919 920 921 922 923 924 925 926 927 928 929 930 931 932 933 934 935 936 937 938 939 940 941 942 943 944 945 946 947 948 949 950 951 952 953 954 955 956 957 958 959 960 961 962 963 964 965 966 967 968 969 970 971 972 973 974 975 976 977 978 979 980 981 982 983 984 985 986 987 988 989 990 991 992 993 994 995 996 997 998 999 1000

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C      SUBROUTINE CARC                                CH 1
C      CARC COMPUTES COEFFICIENTS OF THE CONSTANT (A), SINE (R), AND CH 2
C      COSINE (C) TERMS IN THE CURRENT INTERPOLATION FUNCTIONS FOR THE CH 3
C      CURRENT VECTOR CUR.                                CH 4
C      CH 5
C      CH 6
COMMON /DATA/ N,NP,X(R00),Y(R00),Z(R00),S1(R00),-I1(R00),ALP(R00),
1 BET(R00),ICON1(R00),ICON2(R00),ITAC(R00),ALAM,IP1YM,JMAX
COMMON /CUNT/ AIP(R00),AII(R00),AIC(R00),-I1(R00),C1(R00),CII(R0
10),CUP(R00)
COMMON /JUNK/ NCOX,JOX(25),NCIX,JIX(25),NCOZ,JOZ(25),NCIZ,JIZ(25) CH 11
COMPLEX CUP,CLO,CLL,CLY,AX,RA,CA CH 12
DATA IP/6,283185308/ CH 13
DO 21 I=1,N
CALL TPIO(T,JCO1,JCO2,DIL,DIK)
CLL=TR*CLL
CK=TR*CK
SINK=SIN(CL)
COSL=COS(CL)
SINX=SIN(CK)
COSK=COS(CK)
IF(JCO1.GT.(-90000))GO TO 5
JIX=N-IJCO1+90000
CLO=CUP(JIX)
GO TO 4
5 IF(JCO1)1,6,7
CLO=(0.,0.)
1 IF(NC1,LT,1)GO TO 3
DO 2 K=1,NC1X
JIX=JIX(K)
CLO=CLO+CUP(JIX)
2 IF(NC1,LT,1)GO TO 8
DO 4 K=1,NCOX
JOX=JOX(K)
CLO=CLO-CUP(JOX)
4 GO TO 3
6 CLO=(0.,0.)
GO TO 4
7 CLO=CUP(JCO1)
IF(ICON2(JCO1),NE,I,AND,JCO1,NF,I)CLO=-CLO
8 CLL=CUP(I)
IF(JCO2.GT.(-90000))GO TO 13
JIX=N-IJCO2+90000
CLY=CUP(JIX)
GO TO 14
13 IF(JCO2)9,14,15
CLY=(0.,0.)
9 IF(NC2,LT,1)GO TO 11
DO 10 K=1,NCOZ
JOZ=JOZ(K)
CLY=CLY+CUP(JOZ)
10 IF(NC2,LT,1)GO TO 16
DO 12 K=1,NCIZ
JIZ=JIZ(K)
12 CLY=CLY-CUP(JIZ)
GO TO 16
14 CLY=(0.,0.)
GO TO 16
15 CLY=CUP(JCO2)
IF(ICON1(JCO2),NE,I,AND,JCO2,NF,I)CLY=-CLY
16 IF(JCO1,LT.(-90000))GO TO 17
IF(JCO2,LT.(-90000))GO TO 18
SILK=SINL*COSK-COSL*SINK
CELLO=SINL-SINK-SILK
AX=(CLO*SINK-CLL*SILK-CLY*SINL)/CELLO
RX=(CLO*(COSK-1.)-CLL*(COSL-COSK)+CLY*(1.-COSL))/CELLO
GO TO 20
17 IF(JCO2,LT.(-90000))GO TO 19
SILK=COSL*COSK-SINL*SINK
CELLO=SILK-COSL
AX=(CLO*SINK-CLL*SILK-CLY*COSL)/CELLO
BX=(CLO*(COSK-1.)-(CLL-CLY)*SINL)/CELLO
GO TO 20
18 SILK=COSL*COSK-SINL*SINK
CELLO=COSK-SILK
AX=(CLO*COSK-CLL*SILK-CLY*SINL)/CELLO
RX=(CLO*(COSK-1.)-(CLL-CLY)*SINK-CLY*(1.-COSL))/CELLO
GO TO 20
19 CELLO=2.*SINL*COSL
AX=CLL*(CLY-CLO)*COSL/CELLO
RX=(CLY-CLO)*SINL/CELLO
20 CX=CLL-AX
ATP(I)=REAL(AX)
AII(I)=AIMAG(AX)
BIP(I)=REAL(BX)
BI1(I)=AIMAG(BX)
CIP(I)=REAL(CX)
CII(I)=AIMAG(CX)
21 RETURN
END

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SUBROUTINE CMSET (NPO,NCOL,CM,NLOAD,NMAX)
C
C CMSET SETS UP THE COMPLEX STRUCTURE MATRIX IN THE ARRAY CM
C
COMMON /DATA/ X(NP,NX(ROO),Y(ROO),Z(ROO),ST(ROO),PT(ROO),ALP(ROO),
1 BFT(ROO),ICON(ROO),TCON2(ROO),ITAG(ROO),WLAN,IPRYM,JMAX
DIMENSION CM(NROW,NCOL)
COMMON /MATP3D/ ICASE,NBLOWS,NPRLK,NLAST,NRLSYN,NPSY,NLSYN
COMMON /RESTRI/ IC1,IC2,IC3,NPFS,NPFS,I-LCK
COMMON /ANGUL/ SALP(ROO)
COMMON /JUNK/ NC04,J04(25),NC12,J12(25),NC02,J02(25),NC12,J12(25)
COMMON /REFL/ RHOX,RHOY,RHOZ,CARJ,SARJ,SALPP,PR,PR,REFS,REFPS
COMMON /ZLOAD/ ZADRAY(ROO)
COMMON /GND/ ZPAT1,ZPAT2,CL,CH,SCD,L,SCWD,NRADL,NSTMP,IFAN,IPERF
DIMENSION CAB(1),CAB(1)
DIMENSION ETR(3),ETI(3),EZE(2),EPE(2)
COMPLEX FJ,CM,ZADRAY,C1,EP,ET,EZ,EP,CE1,CE2,CE3
COMPLEX ZPAT1,REFS,REFPS,ZPSIN,ZPATIS,11,ZSCRN,ZPATI2
EQUIVALENCE (CAB(1),ALP(1)), (SAR(1),PT(1)), (E2,EZE), (EP,EPE)
DATA ET4/375.73/P12/4.2831453/P173/14150265/
FUNCTIONS = -
C
C JSEQ(J)=J-1/NP+JMAX
C JSEQ(J)=J-97000*((J-90001)/JMAX+1)*NP
C
NOP=N/4
JPMAX=JMAX/NOP
JEON=0
IF (ICASE.GT.2) RE=IND 11
FJ=(0.,1.)
I2=2*NPRK+NPQW
IBLCK=I2
IT=NPRLK
N11=IC1-1
IF (IC1.EQ.0) GO TO 1
IF (IC1.LE.(-1)) GO TO 22
CALL RLCIN (11,1,I2,IC1,1)
CONTINUE
DO 21 IXRLK=11,NBLOWS
ISV=(IXRLK-1)*NPRLK
IF (IXRLK.EQ.NBLOWS) IT=NLAST
IF (ICASE.LT.3) IT=NCOL
IF (NRADL.EQ.0) GO TO 2
T1=FJ*2367.067/FLOAT(NRADL)
T2=SCD*FJ/FLOAT(NRADL)
ZPATIS=ZPATI
DO 3 I=1,IT
DO 3 J=1,NROW
CM(J,I)=(0.,0.)
ITL=IT
IF (ISV.GE.NP) GO TO 60
IF (ISV.IT.GT.NP) ITL=NP-ISV
C
C SOURCE SEGMENT LOOP
C
DO 18 J=1,N
CALL TP10(J,JCO1,JCO2,DIL,DIK)
S=S1(J)
B=B1(J)
X=X1(J)
Y=Y1(J)
Z=Z1(J)
CARJ=CAR(J)
SARJ=SAR(J)
SALPJ=SALP(J)
C
C OBSERVATION SEGMENT LOOP
C
DO 18 I=1,ITL
I=ISV+I
X1=X(I)-XJ
Y1=Y(I)-YJ
I1=I-J
CAB1=CAB(I)
SAP1=SAP(I)
SALP1=SALP(I)
RFL=-1.
C
C LOOP TO INCLUDE IMAGE OF SOURCE SEGMENT FOR STRUCTURE OVER GROUND.
C
DO 18 IP=1,NSTMP
RFL=RFL
SALPP=SALPP+RFL
Z1J=Z(I)-RFL*ZJ
ZP=X1J*CARJ+Y1J*SARJ+Z1J*SALPP
D1J=CAB1+CABJ+SAB1+SARJ+SALP1+SALPP
RHOX=X1J-CABJ*ZP
RHOY=Y1J-SARJ*ZP
RHOZ=Z1J-SALPP*ZP
RH=SQR1(RHOX**2+RHOY**2+RHOZ**2)
IF (RH.GT.1.E-6) GO TO 4
RHOX=0.
RHOY=0.
RHOZ=0.
DIR=0.
GO TO 5

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4  RM02=R-02/RM CM 86
   RM03=R-03/RM CM 87
   RM04=R-04/RM CM 88
5  D[R]=R-04*CAI-R-03*SAI-R-02*SAI PI CM 89
   R=SQRT(XI*XI+YI*YI+ZI*ZI) CM 90
   IF(IP.NE.2)GO TO 10 CM 90.1
   IJ=1 CM 91
   IF (IPFE.EQ.1) GO TO 10 CM 92
   RMAG=R CM 93
   XYMAG=SQRT(XI*XI+YI*YI) CM 94
C  SET PARAMETERS FOR RADIAL WIRE GROUND SCREEN. CM 95
C  IF (NP0L.EQ.0) GO TO 7 CM 96
   XSPEC=(X(1)*ZJ-Z(1)*XJ)/(Z(1)*ZJ) CM 97
   YSPEC=(Y(1)*ZJ-Z(1)*YJ)/(Z(1)*ZJ) CM 98
   RMOSPC=SQRT(XSPEC*XSPEC+YSPEC*YSPEC+TZ*TZ) CM 99
   IF (RMOSPC.GT.SCRWL) GO TO 6 CM 100
   ZSCRN=1-RMOSPC*ALOG(RMOSPC/TZ) CM 101
   ZRATI=(75CRN*ZRATIS)/(ETA*ZRATIS+75CRN) CM 102
   GO TO 7 CM 103
6  ZRATI=ZRATIS CM 104
7  IF (XYMAG.GT.1.E-5) GO TO 9 CM 105
C  CALCULATION OF REFLECTION COEFFICIENTS WHEN GROUND IS SPECIFIED. CM 106
C  PX=0. CM 107
   PY=0. CM 108
   CTH=1. CM 109
   ZRSIN=(1.-9.) CM 110
   GO TO 9 CM 111
8  PX=YJ/XYMAG CM 112
   PY=XJ/XYMAG CM 113
   CTH=ZJ/RMAG CM 114
   ZPSIN=CSQRT(1.-ZRATI*ZRATI*(1.-CTH*CTH)) CM 115
   REFS=-(CTH-ZRATI*ZPSIN)/(CTH+ZRATI*ZPSIN) CM 116
   REFPS=(ZRATI*CTH-ZPSIN)/(ZRATI*CTH+ZPSIN) CM 117
   REFS=REFPS-REFS CM 118
9  IF(R.GT.PKH)GO TO 58 CM 119
   CALL INTG(R,S,RM+ZP-DIJ,DIP,ETP,ETI,DIL,DIK,IJ,IP,JC01,JC02,XM,YM, CM 120
   I,ZM) CM 121
C  CM 122
C  FILL MATRIX ELEMENTS. ELEMENT LOCATIONS DETERMINED BY CONNECTION CM 123
C  DATA. CM 124
C  CE1=CMPLX(ETR(1),ETI(1)) CM 125
   CE2=CMPLX(ETR(2),ETI(2)) CM 126
   CE3=CMPLX(ETR(3),ETI(3)) CM 127
   IF(JC01.GT.0)JE1=JSEQ(JC01)
   IF(JC01.LT.-90000)JE1=JSEQ(JC01)
   JE2=JSEQ(IJ)
   IF(JC02.GT.0)JE3=JSEQ(JC02)
   IF(JC02.LT.-90000)JE3=JSEQ(JC02)
   IF(JC01.GT.-90000)GO TO 24
   IF(JC02.LT.-90000)GO TO 26
   CE2=CE2-YM/XM*CE1
   CE3=CE3-ZM/XM*CE1
   CM(JE1,IP)=CM(JE1,IP)+CE1/XM
   GO TO 27
24  IF(JC02.GT.-90000)GO TO 27
   CE2=CE2-YM/XM*CE3
   CE1=CE1-ZM/XM*CE3
   CM(JE3,IP)=CM(JE3,IP)+CE3/XM
   GO TO 27
26  DEN=1/(XM*XM-ZM*ZM)
   CE2=CE2-CE1*CE3
   CM(JE3,IP)=CM(JE3,IP)+DEN*(ZM*CE1-XM*CE3)
   CM(JE1,IP)=CM(JE1,IP)+DEN*(XM*CE1-ZM*CE3)
27  IF(JC01.LT.-90000)GO TO 29
   IF(JC01)11-29,12
11  CALL JNELS(CE1,NCIX,JIX,NCIX,JOX,IPR,CH,NROW,NCOL,NP,JPHAX)
   GO TO 29
12  IF(IC02(JC01).EQ.JJGO TO 28
   IF(JC01.EQ.JJGO TO 28
   CM(JE1,IP)=CM(JE1,IP)+CE1
   GO TO 29
28  CM(JE1,IP)=CM(JE1,IP)+CE1
29  CM(JE2,IP)=CM(JE2,IP)+CE2
   IF(JC02.LT.-90000)GO TO 18
   IF(JC02)13-14,14
13  CALL JNELS(CE1,NC0Z,J0Z,NC0Z,J1Z,IPR,CH,NROW,NCOL,NP,JPHAX)
   GO TO 14
14  IF(IC01(JC02).EQ.JJGO TO 30
   IF(JC02.EQ.JJGO TO 30
   CM(JE3,IP)=CM(JE3,IP)+CE3
   GO TO 14
30  CM(JE3,IP)=CM(JE3,IP)+CE3
   GO TO 14
58  RKH=P/2.0 CM 144.1
   AO=2P/3 CM 144.2
   A1=SQRT(ARSE(1.-AO*AO)) CM 144.3
   C1=CMPLX(COS(PKH),-SIN(PKH)) CM 144.4
   E0=S*ETA*AO*CI*CMPLX(1.-1./RKH)/(P1Z*ROD) CM 144.5
   E1=S*ETA*AO*CI*CMPLX(1.-RKH)/(2.*P1Z*ROD) CM 144.6
   E7=ERO*AO-ET*AO CM 144.7
   E0=ERO*1-ET*AO CM 144.8
   IF(IP.FQ.2)CALL GNIEZE(1)+FE(2)+EPE(1)+EPE(2) CM 144.9
   JE2=JSEQ(IJ) CM 144.4
   CM(JE2,IP)=CM(JE2,IP)+DIJ*EZ*H1R*EP

```

```

18 CONTINUE
   IF (IT.EQ.ITL) GO TO 59
   ITL=ITL+1
   GO TO 41
40 ITL=1
41 DO 56 IPR=ITL,IT
   JEIN=JEIN+1
   I=NP-JEIN
   DO 56 J=1,N
   JC01=IC0N1(J)
   JC02=IC0N2(J)
   IF (JC01-99999.NE.JE0N) GO TO 62
   JCAS=2
   IF (JC02.LT.(-99999)) JCAS=4
   GO TO 43
62 IF (JC02-99999.NE.JEQN) GO TO 66
   JCAS=1
   IF (JC01.LT.(-99999)) JCAS=3
63 CALL TP10(J,JC01,JC02,DIL,DIK)
   DIL=PI2*DIK
   DIK=PI2*DIK
   DEN=SIN(DIL)+SIN(DIK)-SIN(DIL+DIK)
   Y=COS(DIL+DIK)
   IF (DIK.LT.DIL) DIL=DIK
   Z=COS(DIL)
   KW=(Y+Z)/DEN
   Y=(1.-Y)/DEN
   Z=(Z-1.)/DEN
   GO TO (57,68,69,70),JCAS
67 IF (JC01.GT.0) JE1=JSEQ(JC01)
   JE2=JSEQ(J)
   CM(JE2,IPR)=CM(JE2,IPR)+Y/XM
   CM(I,IPR)=CM(I,IPR)+1./XM
   IF (JC01.GE.56.73)
68 CE=Z/XM
   CALL JNELS(CE,NCI,JIX,NC0X,J0X,IPR,CM,N,NCOL,NP,J=AX)
   GO TO 44
73 IF (IC0N2(JC01).EQ.J) GO TO 71
   IF (JC01.EQ.J) GO TO 71
   CM(JE1,IPR)=CM(JE1,IPR)-Z/XM
   GO TO 45
71 CM(JE1,IPR)=CM(JE1,IPR)+Z/XM
   GO TO 45
69 JE2=JSEQ(J)
   IF (JC02.GT.0) JE3=JSEQ(JC02)
   CM(JE2,IPR)=CM(JE2,IPR)+Y/XM
   CM(I,IPR)=CM(I,IPR)+1./XM
   IF (JC02.GE.56.75)
70 CE3=Z/XM
   CALL JNELS(CE3,NC0Z,J0Z,NCIZ,J1Z,IPR,CM,N,NCOL,NP,J=BX)
   GO TO 46
75 IF (IC0N1(JC02).EQ.J) GO TO 72
   IF (JC02.EQ.J) GO TO 72
   CM(JE3,IPR)=CM(JE3,IPR)+Z/XM
   GO TO 65
72 CM(JE3,IPR)=CM(JE3,IPR)-Z/XM
   GO TO 46
65 JE2=JSEQ(J)
   JE1=NP-(JC01-99999)
   DEN=1./(Z+ZM-XM*XM)
   CM(JE2,IPR)=CM(JE2,IPR)+1.
   CM(I,IPR)=CM(I,IPR)+XM*DEN
   CM(JE1,IPR)=CM(JE1,IPR)-ZM*DEN
   GO TO 46
70 JE2=JSEQ(J)
   JE1=NP-(JC02-99999)
   DEN=1./(ZM+ZM-XM*XM)
   CM(JE2,IPR)=CM(JE2,IPR)+1.
   CM(I,IPR)=CM(I,IPR)+XM*DEN
   CM(JE1,IPR)=CM(JE1,IPR)-ZM*DEN
66 CONTINUE
69 IF (NPACL.NE.0) ZPATI=ZPATIS
.....
***** MATRIX ELEMENTS MODIFIED BY LOADING *****
   IF (MCAD.EQ.0) GO TO 20
   DO 19 I=1,IT
   JE1SV=I
   IF (J.ST.NP) GO TO 20
   CM(JE1,IPR)=CM(JE1,IPR)-ZAPRAY(J)
21 IF (ICASE.LT.3) GO TO 21
   CALL BLOCKT (I1,I2,I3)
   ICI=ICL(I)
   IF (ICI.EQ.NBLOKS) GO TO 21
   CALL CHKPR
22 CONTINUE
   IF (ICASE.LT.3) GO TO 22
   PE=IND I1
   ICI=2
   IF (ICASE.EQ.3) ICI=-1
   CALL CHKPR
23 PE=JDN
   END

```

CM 145

CM 146
 CM 147
 CM 148
 CM 149
 CM 150
 CM 151
 CM 152
 CM 153
 CM 154
 CM 155
 CM 156
 CM 157
 CM 158
 CM 159
 CM 160
 CM 161
 CM 162
 CM 163
 CM 164
 CM 165
 CM 166-

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[illegible]

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IF (IZ.EQ.2) GO TO 203
IX=ICON1(I)
IF (IX.LT.(-90000)) GO TO 111
IF (IX.EQ.0.OR.IX.EQ.1) GO TO 111
JMAX=JMAX+1
IZ=-JMAX+90000
ICON1(I)=IZ
GO TO 204
203 IX=ICON2(I)
IF (IX.LT.(-90000)) GO TO 111
IF (IX.EQ.0.OR.IX.EQ.1) GO TO 111
JMAX=JMAX+1
IZ=-JMAX+90000
ICON2(I)=IZ
204 IF (IX.LT.0) GO TO 205
IF (ICON1(IX).EQ.1) GO TO 206
ICON2(IX)=IZ
GO TO 111
206 ICON1(IX)=IZ
GO TO 111
205 DO 207 I=1,N
IF (ICON1(I).EQ.IX) ICON1(I)=IZ
IF (ICON2(I).EQ.IX) ICON2(I)=IZ
207 CONTINUE
GO TO 111
208 IF (JMAX.GT.0) GO TO 212
DO 210 I=1,N
IX=0
IY=-1
IZ=-JMAX+90001
DO 209 J=1,N
IF (ICON1(J).NE.IY) GO TO 211
IX=1
ICON1(J)=IZ
GO TO 209
211 IF (ICON2(J).NE.IY) GO TO 209
IX=1
ICON2(J)=IZ
209 CONTINUE
IF (IX.EQ.0) GO TO 213
JMAX=JMAX+1
210 CONTINUE
213 IF (GM.FQ.ATST(8)) RETURN
GO TO 111
10 PRINT 19
PRINT 20, GM, ITG, NS, XW1, YW1, ZW1, XW2, YW2, ZW2, RAD
STOP
C
11 FORMAT (////,33X,35H- - - STRUCTURE SPECIFICATION - - -//,37X,
1 28HCOORDINATES MUST BE INPUT IN//,37X,
2 29H METERS OR BE SCALED TO METERS//,37X,
3 31HBEFORE STRUCTURE INPUT IS ENDED//)
12 FORMAT ( 2X,4HWIRE,79X,6HNO. OF,4X,5HFIRST,2X,4- LAST,5X,3H TAG,
1 /,2X,3HNO.,8X,2H1,9X,2H1,9X,2H2,10X,2H2,9X,2- Y2,4X,2- Z2,6X,
2 6H RADIUS,3X,4H SEG.,5X,4H SEG.,7X,4H SEG.,5X,3HNO.)
13 FORMAT (A2,I3,I5,7F10.5)
14 FORMAT (1X,I5,3F11.5,1X,4F11.5,2X,I5,4X,I5,1X,I5,7X,I5)
15 FORMAT (6X,34HSTRUCTURE REFLECTED ALONG THE AXES,3(I,X,A1))
1 22H. TASS INCREMENTED BY,I5)
16 FORMAT (6X,30HSTRUCTURE ROTATED ABOUT Z-AXIS,I3,
1 30H TIMES. LABLES INCREMENTED BY,I5)
17 FORMAT (6X,26HSTRUCTURE SCALED BY FACTOR,F10.5)
18 FORMAT (6X,49HTHE STRUCTURE HAS BEEN MOVED. MOVE DATA CARD IS -/
1 6X,I3,I5,7F10.5)
19 FORMAT (25H GEOMETRY DATA CARD ERROR)
20 FORMAT (1X,A2,I3,I5,7F10.5)
90 FORMAT (////,46H JUNCTIONS USING OPTIONAL INTERPOLATION METHOD)
91 FORMAT (A2,I3,2I5)
93 FORMAT (1X,A2,I3,2I5)
92 FORMAT (69H ERROR-- INVALID DATA CARD WHERE JUNCTION INTERPOLATION
ICARD EXPECTED)
END

```

DA 84
DA 85
DA 86
DA 87
DA 88
DA 89
DA 90
DA 91
DA 92
DA 93
DA 94
DA 95
DA 96
DA 97
DA 98
DA 99
DA 100
DA 101
DA 102
DA 103
DA 104
DA 105

DA 106-

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	SUBROUTINE FACTR (N,N,IP,NDIM)	FA 1
C		FA 2
C	SUBROUTINE TO FACTOR A MATRIX INTO A UNIT LOWER TRIANGULAR MATRIX	FA 3
C	AND AN UPPER TRIANGULAR MATRIX USING THE GAUSS-JORDAN ALGORITHM	FA 4
C	PRESENTED ON PAGES 411-414 OF A. RALSTON--A FIRST COURSE IN	FA 5
C	NUMERICAL ANALYSIS. COMMENTS BELOW REFER TO COMMENTS IN RALSTON'S	FA 6
C	TEXT. (MATRIX TRANSPOSE)	FA 7
C		FA 8
C	DIMENSION A(NDIM,NDIM), IP(NDIM)	FA 9
	COMMON /SCPATM/ D(NDIM)	
	COMPLEX A,D,ARJ	FA 11
	INTEGER R,RM1,RP1,PJ,PP	FA 12
	IFLG=0	FA 13
	DO 9 R=1,N	FA 14
C		FA 15
C	STEP 1	FA 16
C		FA 17
	DO 1 K=1,N	FA 18
	D(K)=A(P,K)	FA 19
1	CONTINUE	FA 20
C		FA 21
C	STEPS 2 AND 3	FA 22
C		FA 23
	RM1=R-1	FA 24
	IF (RM1.LT.1) GO TO 4	FA 25
	DO 3 J=1,RM1	FA 26
	PJ=IP(J)	FA 27
	ARJ=D(PJ)	FA 28
	A(P,J)=ARJ	
	D(PJ)=D(J)	FA 29
	JP1=J+1	FA 30
	DO 2 I=JP1,N	FA 31
	D(I)=D(I)-A(I,J)*ARJ	
2	CONTINUE	FA 33
3	CONTINUE	FA 34
4	CONTINUE	FA 35
C		FA 36
C	STEP 4	FA 37
C		FA 38
	DMAX=REAL(D(R))*CONJG(D(R))	FA 39
	IP(R)=R	FA 40
	RP1=R-1	FA 41
	IF (RP1.GT.N) GO TO 6	FA 42
	DO 5 I=RP1,N	FA 43
	ELMAG=REAL(D(I))*CONJG(D(I))	FA 44
	IF (ELMAG.LT.DMAX) GO TO 5	FA 45
	DMAX=ELMAG	FA 46
	ID(I)=I	FA 47
5	CONTINUE	FA 48
A	CONTINUE	FA 49
	IF (DMAX.LT.1.E-10) IFLG=1	FA 50
	PP=IP(R)	FA 51
	A(P,R)=D(PP)	FA 52
	D(PP)=D(R)	FA 53
C		FA 54
C	STEP 5	FA 55
C		FA 56
	IF (RP1.GT.N) GO TO 8	FA 58
	ARJ=1./A(P,R)	FA 59
	DO 7 I=RP1,N	FA 60
	A(P,I)=D(I)*ARJ	FA 61
7	CONTINUE	FA 62
8	CONTINUE	FA 63
	IF (IFLG.EQ.0) GO TO 9	FA 64
	PRINT 10, R,DMAX	FA 65
	IFLG=1	FA 66
9	CONTINUE	FA 67
	RETURN	FA 68
C		FA 69
10	FORMAT (1H,6HP1V(1,1),2H,2F(4,8)	
	END	

```

SUBROUTINE INTG(R,S,RH,ZP,DIJ,NIR,ETR,ETI,DIL,DIK,IJ,IP,JCO1,JCO2,
1 XM,YM,ZM)
C
C INTG COMPUTES THREE COMPLEX FIELD COMPONENTS THAT MULTIPLY THE
C THREE SEGMENT CURRENTS USED IN INTERPOLATING OVER A SEGMENT.
C THESE COMPONENTS, ETR AND ETI, GO INTO THE INTERACTION MATRIX.
C
C DIMENSION ETR(3), ETI(3)
C DATA TP/6.283185308/
C
C COMPUTE TANGENTIAL FIELD ON OBSERVATION SEGMENT DUE TO SINE,
C COSINE, AND CONSTANT CURRENTS ON SOURCE SEGMENT.
C
C CALL EFLD (R,S,RH,ZP,IJ,EZRS,EZIS,ERRS,ERIS,EZRC,EZIC,ERRC,ERIC,
1 EZRK,EZIK,ERRK,ERIK)
C IF (IP,NE.2) GO TO 1
C CALL GN (EZRS,EZIS,ERRS,ERIS)
C CALL GN (EZRC,EZIC,ERRC,ERIC)
C CALL GN (EZRK,EZIK,ERRK,ERIK)
C ETPS=EZRS*DIJ+ERRS*DIP
C ETIS=EZIS*DIJ+ERIS*DIP
C ETRC=EZRC*DIJ+ERRC*DIP
C ETIC=EZIC*DIJ+ERIC*DIP
C ETRK=EZRK*DIJ+ERRK*DIP
C ETIK=EZIK*DIJ+ERIK*DIP
C
C COMPUTE INTERPOLATION COEFFICIENTS AND FORM THE COEFFICIENTS OF
C THE THREE SEGMENT CURRENTS USED IN CURRENT INTERPOLATION.
C
C CL=TP*DIL
C CK=TP*DIK
C SINL=SIN(CL)
C COSL=COS(CL)
C SINK=SIN(CK)
C COSK=COS(CK)
C SILK=SIN(CL*CK)
C CONS=SINL*SINK-SILK
C ETR(1)=(SINK*ETRK-(COSK-1.)*ETPS-SINK*ETRC)/CONS
C ETI(1)=(SINK*ETIK-(COSK-1.)*ETIS-SINK*ETIC)/CONS
C ETR(2)=(-SILK*ETRK-(COSL-COSK)*ETPS+(SINL-SINK)*ETRC)/CONS
C ETI(2)=(-SILK*ETIK-(COSL-COSK)*ETIS+(SINL-SINK)*ETIC)/CONS
C ETR(3)=(SINL*ETRK+(1.-COSL)*ETPS-SINL*ETRC)/CONS
C ETI(3)=(SINL*ETIK+(1.-COSL)*ETIS-SINL*ETIC)/CONS
C IF (JCO1,LT.(-90000)) GO TO 2
C IF (JCO2,LT.(-90000)) GO TO 3
C RETURN
C
C COSL=COSK
C SILK=COS(CL*CK)
C XM=(SILK-COSL)/CONS
C YM=(1.-SILK)/CONS
C ZM=(COSL-1.)/CONS
C RETURN
C
C END

```

```

SUBROUTINE JNELS(CMEL,NCP,JP,NCM,JM,I,CM,NROW,NCOL,NP,JPHAX)
C
C JNELS SUMS THE CONTRIBUTIONS TO THE MATRIX ELEMENTS FOR SEGMENTS
C CONNECTED TO JUNCTIONS OF THREE OR MORE SEGMENTS
C
C DIMENSION CM(NROW,NCOL)
C DIMENSION JP(25), JM(25)
C COMPLEX CM,CMEL
C IF (NCP,LT.1) GO TO 2
C DO 1 J=1,NCP
C JP(J)=(JP(J)-1)/NP*JPHAX
C CM(JP,J,I)=CM(JP,J,I)+CMEL
C CONTINUE
C IF (NCM,LT.1) GO TO 4
C DO 3 J=1,NCM
C JM(J)=(JM(J)-1)/NP*JPHAX
C CM(JM,J,I)=CM(JM,J,I)+CMEL
C CONTINUE
C RETURN
C
C END

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C SUPROUTINE LFACTR (A,NROW,NCOL,IX1,IX2,IP) LF 1
C LF 2
C LFACTR PERFORMS GAUSS-DOOLITTLE MANIPULATIONS ON THE TWO BLOCKS OF LF 3
C THE TRANSPOSED MATRIX IN CORE STORAGE. THE GAUSS-DOOLITTLE LF 4
C ALGORITHM IS PRESENTED ON PAGES 411-414 OF A. HALSTON -- A FIRST LF 5
C COURSE IN NUMERICAL ANALYSIS. COMMENTS BELOW REFER TO COMMENTS IN LF 6
C HALSTON'S TEXT. LF 7
C LF 8
C COMMON /MATPAR/ ICASE,NBLOCKS,NPBLK,NLAST,NBLSYM,NPSYM,NLSYM LF 9
C COMMON /SCRATCH/ D(NROW)
C DIMENSION A(NROW,NCOL), IP(NROW) LF 11
C COMPLEX A(0:AJR) LF 12
C INTEGER R,R1,R2,DOJNDW LF 13
C LOGICAL L1,L2,L3 LF 14
C IFLG=0 LF 15
C LF 16
C INITIALIZE R1,R2,J1,J2 LF 17
C LF 18
C L1=IX1.EQ.1.AND.IX2.EQ.2 LF 19
C L2=(IX2-1).EQ.IX1 LF 20
C L3=IX2.EQ.NBLOCKS LF 21
C IF (L1) GO TO 1 LF 22
C GO TO 2 LF 23
1 R1=1 LF 24
R2=2*NPBLK LF 25
J1=1 LF 26
J2=-1 LF 27
GO TO 5 LF 28
2 R1=NPBLK+1 LF 29
R2=2*NPBLK LF 30
J1=(IX1-1)*NPBLK+1 LF 31
IF (L2) GO TO 3 LF 32
GO TO 4 LF 33
3 J2=J1+NPBLK-2 LF 34
GO TO 5 LF 35
4 J2=J1+NPBLK-1 LF 36
5 IF (L3) R2=NPBLK+NLAST LF 37
DO 16 P=R1,R2 LF 38
C LF 39
C STEP 1 LF 40
C LF 41
C DO 6 K = J1,NROW LF 42
D(K)=A(K,R) LF 43
CONTINUE LF 44
A LF 45
C STEPS 2 AND 3 LF 46
C LF 47
C IF (L1.OR.L2) J2=J2-1 LF 48
C IF (J1.GT.J2) GO TO 9 LF 49
IXJ=0 LF 50
DO 8 J=J1,J2 LF 51
IXJ=IXJ+1 LF 52
PJ=IP(J) LF 53
AJR=D(PJ) LF 54
A(J,R)=AJR
D(PJ)=D(J) LF 55
J0=J+1 LF 56
DO 7 I = J01,NROW LF 57
D(I)=D(I)-A(I,IXJ)*AJR LF 58
CONTINUE LF 59
CONTINUE LF 60
CONTINUE LF 61
C LF 62
C STEP 4 LF 63
C LF 64
C J2P1=J2+1 LF 65
C IF (L1.OR.L2) GO TO 11 LF 66
C IF (NROW.LT.J2P1) GO TO 14 LF 67
DO 10 I = J2P1,NROW LF 68
A(I,R)=D(I) LF 69
10 CONTINUE LF 70
GO TO 16 LF 71
11 DMAX=REAL(D(J2P1)*CONJ(D(J2P1))) LF 72
IP(J2P1)=J2P1 LF 73
J2P2=J2+2 LF 74
IF (J2P2.GT.NROW) GO TO 13 LF 75
DO 12 I = J2P2,NROW LF 76
ELMAG=REAL(D(I)*CONJ(D(I))) LF 77
IF (ELMAG.LT.DMAX) GO TO 12 LF 78
DMAX=ELMAG LF 79
IP(J2P1)=I LF 80
CONTINUE LF 81
CONTINUE LF 82
13 IF (DMAX.LT.1.E-10) IFLG=1 LF 83
PR=IP(J2P1) LF 84
A(J2P1,0)=D(PR) LF 85
D(PR)=D(J2P1) LF 86
C LF 87
C STEP 5 LF 88
C LF 89
C IF (J2P2.GT.NROW) GO TO 15 LF 90
AJJ=1./A(J2P1,0) LF 91
DO 14 I=J2P2,NROW LF 92
A(I,R)=D(I)*AJJ LF 93
14 CONTINUE

```

```

15 CONTINUE
   IF (IFLG.EQ.0) GO TO 15
   PRINT 17, J2,CM1
   IFLG=0
16 CONTINUE
   RETURN
C
C
17 FORMAT (1H 6SPRIVOT(1,13,2H)=,F16.4)
END

```

```

LF 94
LF 95
LF 96
LF 97
LF 98
LF 99
LF 100
LF 101
LF 102
LF 103-

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```

C SUBROUTINE SOLVES (NOP,A,IP,H,NPQ,NCOL,IX,NP,N,JPMAX)
C
C SUBROUTINE SOLVES FOR SYMMETRIC STRUCTURES. HANDLES THE
C TRANSFORMATION OF THE RIGHT HAND SIDE VECTOR AND SOLUTION OF THE
C MATRIX EQ.
C
COMMON /SMAT/ S(10,10)
DIMENSION A(NPQ,NCOL), IP(N), IX(N), H(N)
COMMON /SCMAT/ Y(100)
COMMON /MATPAD/ ICASE,NBLOKS,NBPK,NLAST,NRLSYM,NOSYM,NLSYM
COMPLEX A,B,Y,SUM,S
NPEQ=NQ
IF(JPMAX.EQ.0)GO TO 15
NPEQ=NQ+JPMAX
NEQ=N+JPMAX+NQ
IF(NQ.EQ.1)GO TO 25
DO 16 I=NP,N
Y(I)=R(I)
16 IB=NP
25 IA=NP
DO 17 I=1,NQ
IF(I.EQ.1)GO TO 26
DO 18 J=1,NP
IA=IA+1
IB=IB+1
18 B(IA)=Y(IB)
26 DO 19 J=1,JPMAX
IA=IA+1
19 B(IA)=(0.,0.)
17 CONTINUE
15 IF(NQ.EQ.1)GO TO 5
FNOP=NQ
FNORM=1./FNOP
C
C TRANSFORM MATRIX EQ. RHS VECTOR ACCORDING TO SYMMETRY MODES
C
DO 4 I=1,NPEQ
DO 1 K=1,NQ
IA=I+(K-1)*NPEQ
Y(K)=B(IA)
1 SUM=Y(I)
DO 2 K=2,NQ
SUM=SUM+Y(K)
2 B(I)=SUM*FNORM
DO 4 K=2,NQ
IA=I+(K-1)*NPEQ
SUM=Y(I)
DO 3 J=2,NQ
SUM=SUM+Y(J)*CONJG(S(K,J))
3 B(IA)=SUM*FNORM
4 IF (ICASE.LT.1) GO TO 6
REWIND 15
REWIND 16
C
C SOLVE EACH MODE EQUATION
C
DO 10 KK=1,NQ
IA=(KK-1)*NPEQ+1
IB=IA
IF (ICASE.NE.4) GO TO 4
DO 7 I = 1, NPEQ
7 READ (15) (AT(J,I),J=1,NPEQ)

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COPY AVAILABLE TO DDC DOES NOT
 PERMIT FULLY LEGIBLE PRODUCTION

COPY AVAILABLE TO DDC DOES NOT
PERMIT FULL SCALE PRODUCTION

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      IR=1
      IF (ICASE.EQ.1.OR.ICASE.EQ.5) GO TO 9
      CALL SOLVE (INPEQ, A(IH,1), IP(IH), R(IH), N=0)
      GO TO 10
9     CALL LTSOLV (A,NPEQ,NCOL,IX(IH),R(IH))
10    CONTINUE
      IF (INPEQ.EQ.1) GO TO 20
C     INVERSE TRANSFORM THE MODE SOLUTIONS
C
      DO 14 I=1,NPEQ
      DO 11 K=1,NOP
      IA=I+(K-1)*NPEQ
      Y(K)=R(IA)
11    SUM=Y(I)
      DO 12 J=2,NOP
      SUM=SUM+Y(K)
12    R(I)=SUM
      DO 14 K=2,NOP
      IA=I+(K-1)*NPEQ
      SUM=Y(I)
      DO 13 J=2,NOP
      SUM=SUM+Y(J)*S(K,J)
13    R(IA)=SUM
14    IF (JPMAX.EQ.0.OP.N.EQ.NP) RETURN
      DO 21 I=NP,NEQ
      Y(I)=R(I)
      IA=NP
      IB=N
      K=NP
      DO 22 I=1,NOP
      IF (I.EQ.1) GO TO 27
      DO 23 J=1,NP
      IA=IA+1
      K=K+1
23    R(IA)=Y(K)
      DO 24 J=1,JPMAX
      IB=IB+1
      K=K+1
24    R(IB)=Y(K)
22    CONTINUE
      RETURN
      END

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C     SUBROUTINE TRIO (J,JC01,JC02,DIL,DIK)
C     SUBROUTINE TRIO DETERMINES WHICH SEGMENTS ARE CONNECTED TO SEGMENT
C     J. SUBROUTINE JUNC IS CALLED TO FILL COMMON/JUNK/ FOR MULTIPLE
C     JUNCTIONS.
C
      COMMON /DATA/ N,NP,X(800),Y(800),Z(800),SI(800),PI(800),ALPI(80),
      I BET(800),IC01(800),IC02(800),IT45(800),WLAH,IPSYH,JMAX
      COMMON /JUNK/ NCOX,JOX(25),NCIX,JIX(25),NCOZ,JOZ(25),NCIZ,JIZ(25)
      S=SI(J)
      JC01=IC01(J)
      JC02=IC02(J)
      IF (JC01.LT.(-90000)) GO TO 2
      IF (JC01) 1=2,3
1     CALL JUNC (J,JC01,NCOX,JOX,NCIX,JIX,DIL)
      GO TO 4
2     DIL=S/2.0
      GO TO 4
3     DIL=(SI(JC01)+S)/2.0
      IF (JC02.LT.(-90000)) GO TO 4
      IF (JC02) 5=6,7
5     CALL JUNC (J,JC02,NCOZ,JOZ,NCIZ,JIZ,DIK)
      GO TO 8
6     DIK=S/2.0
      GO TO 8
7     DIK=(SI(JC02)+S)/2.0
8     CONTINUE
      RETURN
      END

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